The Engineer

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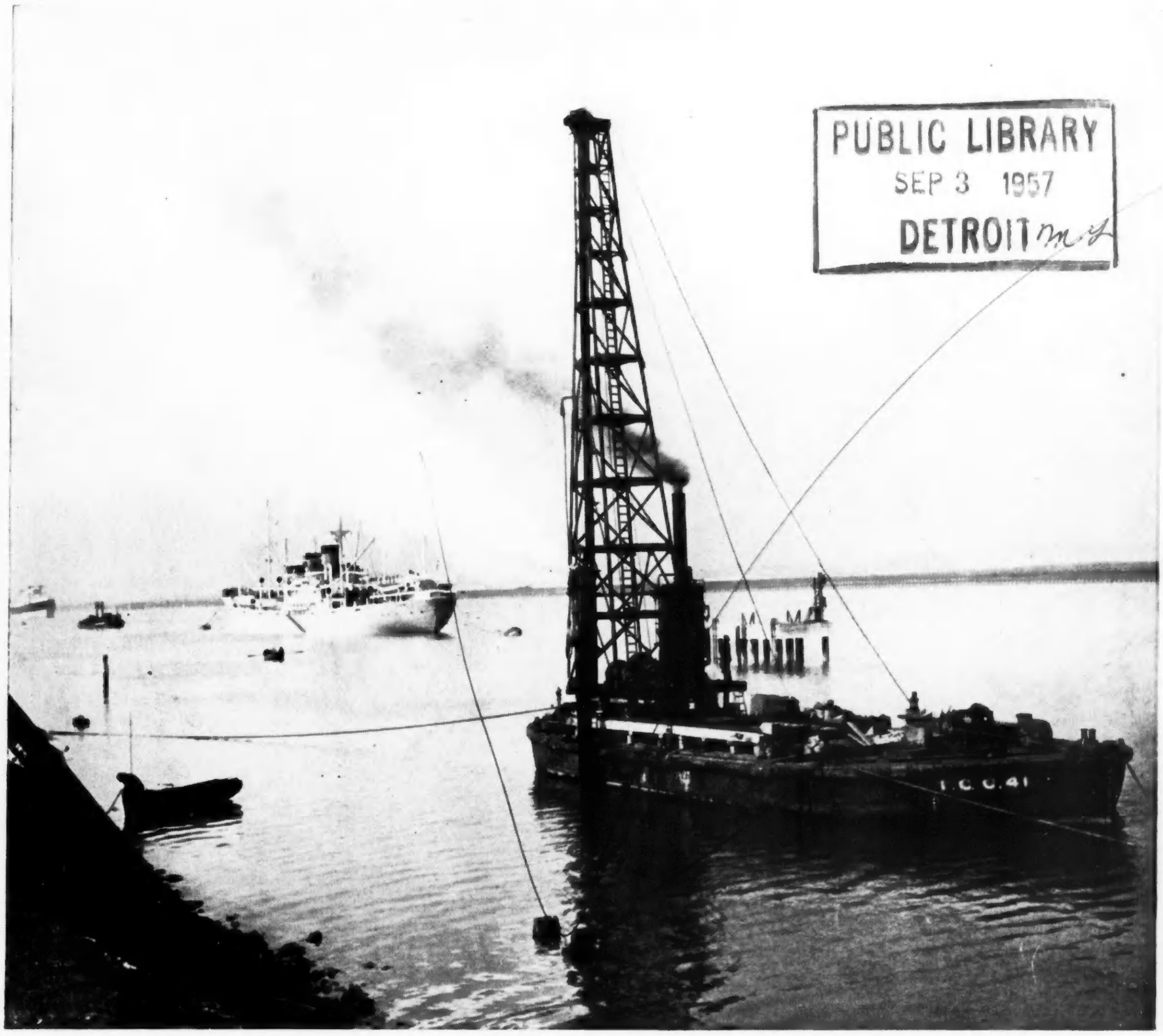

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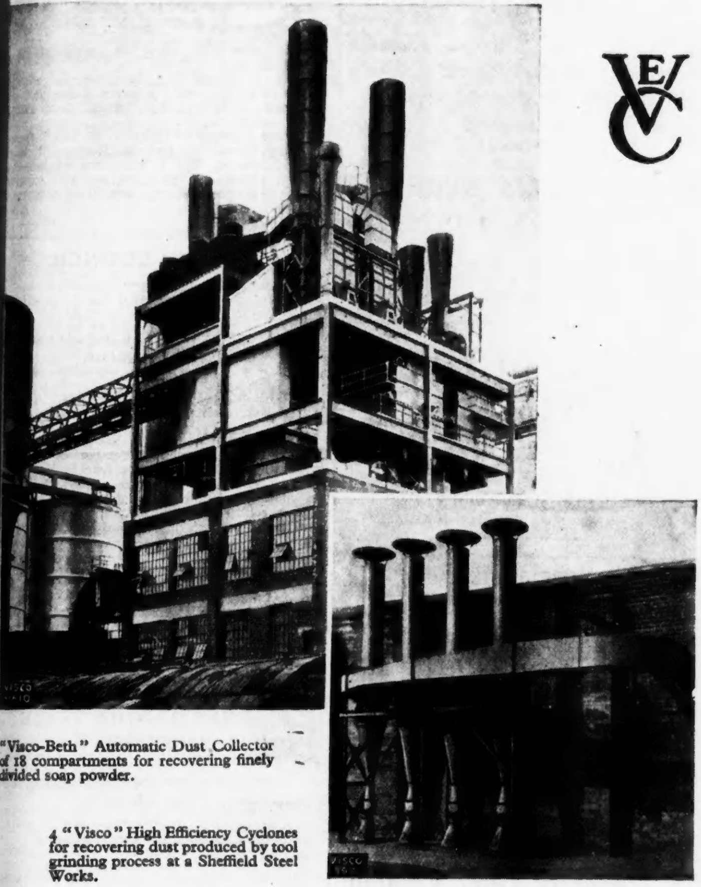

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THE ENGINEER

ESTABLISHED 1856
28 ESSEX STREET, STRAND, LONDON, W.C.2.
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Catalogues, when ready, may be obtained of Messrs. FULLER HORSEY SONS & CASSELL, Industrial Auctioneers & Valuers, 10, Lloyd's Avenue, London, E.C.3. E7841 J

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PUBLIC APPOINTMENTS

FOURAH BAY COLLEGE, SIERRA LEONE

(UNIVERSITY OF DURHAM)

SENIOR LECTURER AND LECTURER IN ENGINEERING

Applications are invited for the posts of SENIOR LECTURER and LECTURER IN ENGINEERING The Department will provide courses in Civil, Electrical and Mechanical Engineering to Diploma level. Applicants should have had previous experience in an Institution of higher education. Membership of main professional Engineering Institution an advantage.

Appointments normally pensionable but shorter term appointments on contract could be arranged. SALARY SCALES :

Senior Lecturer : £1452 by £47 to £1640 ; £1707 ; £1804 by £47 to £1898.

Lecturer : £880 by £42 to £1006 ; £1098 by £42 to £1266 ; E.B. £1308, £1350, £1442 by £42 to £1610.

Entry point according to qualifications and experience.

Other conditions include children's allowances (max. £300), passages, generous leave and partly furnished accommodation, rental not exceeding 7½ per cent of salary.

Further information may be obtained from the Secretary, Council for Overseas Colleges, 1, Woburn Square, London, W.C.1, to whom applications (6 copies), giving age, qualifications and experience, and naming three referees, should be sent by 12th September, 1957. E7978

BRITISH COUNCIL

CHILE

PROFESSORSHIP OF MECHANICAL ENGINEERING

PROFESSORSHIP OF MECHANICAL ENGINEERING, Santa Maria Technical University, Valparaiso.

The British Council, in co-operation with the British Latin American Chamber of Commerce, invites applications for this post from British graduates with university or technical college teaching experience. The Professor would instruct in engineering laboratory work, and teach the theory of internal combustion engineering, hydraulic machinery, and steam and gas turbines. He should be ready to acquire Spanish.

Emoluments equivalent at present rates to £2300 a year. Three year contract, renewable. Return fares paid.

Write, quoting N2(57) and enclosing stamped addressed foolscap envelope to Director, Personnel Department, British Council, 65, Davies Street, London, W.1, to be returned completed by Friday, 30th August. E7966

PENNSYLVANIA STATE UNIVERSITY

DEPARTMENT OF ENGINEERING MECHANICS

ASSISTANT PROFESSOR

Position available for ASSISTANT PROFESSOR to do research and teach undergraduate and graduate courses in Engineering Mechanics. Also opportunity to develop Vibrations Laboratory. Someone with Doctor's Degree preferred.—Write, Joseph Marin, Department of Engineering Mechanics, the Pennsylvania State University, University Park, Pennsylvania, for further details. E7559

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E. R.

By Order of the Minister of Supply

GOVERNMENT SURPLUS STORES
TO BE SOLD BY AUCTION

AUCTION PROGRAMME

		Main Location of Stores	Auctioneers
August 28–30	Machine tools and miscellaneous stores, including a large number of industrial sewing machines	Central Ordnance Depot, Old Dalby, Melton Mowbray, Leicestershire. (Sale at Melton Mowbray.)	SHOULER & SON (Dept. L), 1, Norman St., Melton Mowbray, Leicestershire. (Tel. 81.)
September 4	Miscellaneous stores, including furniture, kitchen utensils, barrows, bicycle spares, canvas	General Stores Sub-Depot, Longtown, Nr. Carlisle	HARRISON & HETHERINGTON LTD.(Dept. L), Botchergate, Carlisle. (Tel. 26292/3.)
September 3–6	*Vehicles, lifting and earth moving equipment	M.O.S. Storage Depot, Ruddington, Notts.	WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel. 47271.)
September 10–12	Vehicles, machine tools and miscellaneous stores	M.O.S. Storage Depot, Royal Arsenal, Woolwich, London, S.E.18	FULLER, HORSEY, SONS & CASSELL (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel. Royal 4861.)
September 17–18	Miscellaneous stores, including large quantity of motor tyres	M.O.S. Storage Depot, Rotherwas, Hereford	RUSSELL, BALDWIN & BRIGHT, LTD. (Dept.) L), 20, King St., Hereford. Tel. 4366.

* 2300 motor vehicles, earth moving plant, lifting equipment, trailers, plant ancillaries and spares, diesel power units, &c., to be sold from the M.O.S. Storage Depot, Ruddington, Nr. Nottingham, on September 3–6, will include 80 saloons and limousines, 90 diesel chassis, refuellers, tractors, trucks and vans, 265 jeeps, 20 and 40-ton transporter and low loading trailers, excavators, 102 cranes, tractors and dozers, scrapers, graders, dumpers, 360 diesel engine units by Caterpillar and International, &c.

CATALOGUES (6d. each—P.O.'s only) available from the Auctioneers shown above. E975 J

PUBLIC APPOINTMENTS

UNIVERSITY OF DURHAM

KING'S COLLEGE, NEWCASTLE UPON TYNE

LECTURESHIP IN NAVAL ARCHITECTURE

The Council of King's College invite applications for a LECTURESHIP IN NAVAL ARCHITECTURE. Applicants should hold a Degree in Naval Architecture or an equivalent academic qualification, and should preferably have been engaged on practical shipbuilding for several years, or in design or research work connected with shipbuilding. Previous teaching experience is not essential, but will be taken into consideration in making the appointment.

The commencing salary will be fixed at a suitable point on the scale £900 by £50 to £1350 (Bar) by £75 to £1650 per annum, with F.S.S.U. and family allowance.

Twelve copies of application, together with the names of three persons to whom reference may be made, should be submitted not later than 30th September, 1957, to the undersigned, from whom further particulars may be obtained.

G. R. HANSON,
E7943 Registrar of King's College.

UNIVERSITY OF MALAYA, SINGAPORE

DEPARTMENT OF ENGINEERING

LECTURESHIP

Applications are invited from graduates with recognised professional qualifications for LECTURESHIP in Department of Engineering. Salary £1148 by £49 to £1442/£1540 by £56 to £1820 p.a., entry point determined by qualifications and experience. Allowances: expatriation £280–£308 p.a., cost of living £210–£560 p.a., all paid in Malayan currency. Passages for appointee, wife and children under 12 years. Part-furnished quarters at reasonable rent. Provident fund scheme. Duties to be assumed as soon as possible.

Detailed applications (6 copies), naming 3 referees, by 9th September, 1957, to Secretary, Inter-University Council for Higher Education Overseas, 29, Woburn Square, London, W.C.1, from whom further particulars may be obtained. E7927

CENTRAL ELECTRICITY AUTHORITY

SOUTH EASTERN DIVISION

KINGSTON "B" POWER STATION

ASSISTANT ENGINEER (PROJECTS)

An ideal opportunity exists for entrance to the power supply industry. The successful applicant will be responsible for handling all work in connection with additions and modifications at Kingston Power Station—from the initial preparation stage, where alternative designs are being considered to the preparation of specifications and drawings suitable for sending to firms for quotations—and later following through the work being carried out by contractors on site.

Possession of H.N.C. in Mechanical or Electrical Engineering or its equivalent desirable. Salary Class G, Grade 9, £885 to £930 per annum, including London allowance.

Applications, giving details of education, present position, experience, &c., should be sent to the Station Superintendent, Kingston "B" Power Station, Downhall Road, Kingston, so as to arrive by 24th August, quoting reference (308). E7928

NATIONAL RESEARCH DEVELOPMENT CORPORATION

TWO JUNIOR ELECTRICAL ENGINEERS

National Research Development Corporation requires TWO JUNIOR ELECTRICAL ENGINEERS, one knowing the specialities of the different firms in the industry and having some experience of patents procedure and licensing, to help with the technical evaluation and commercial exploitation of inventions in the electronics field generally; the other, with some administrative experience, a taste for mathematics, and the ability to help with framing, and programming for, a data processing system employing an electronic digital computer) to meet a specific industrial need.

Degree or professional qualifications desirable. Good and progressive salary according to qualifications and experience. Five-day week, contributory pension scheme.—Application forms from N.R.D.C., , Tilney Street, London, W.1. E7919

NATIONAL COAL BOARD

SOUTH WESTERN DIVISION

SENIOR ENGINEERING DRAUGHTSMAN

The National Coal Board, South Western Division, invite applications for the post of SENIOR ENGINEERING DRAUGHTSMAN in the Divisional Carbonisation Department, Nantgarw, Glam.

Applicants should possess knowledge of plant layout, drainage, sewerage, tanks, gantries conveyors, structural steelwork, &c.

Salary range £715–£965 per annum.

Please quote Staff Vacancy No. 352.

Full particulars of age, qualifications, experience and positions held, together with details of present post and salary, should be sent to the Divisional Chief Staff Officer, National Coal Board, Cambrian Buildings, Mount Stuart Square, Cardiff, by 20th August, 1957. E7866

PUBLIC APPOINTMENTS

NEW ZEALAND MINISTRY OF WORKS

PROFESSIONAL & TECHNICAL STAFF

The Ministry of Works, New Zealand, invites applications for the following vacancies on the permanent staff. Positions, qualifications desired and commencing salaries are as follows :—

CIVIL ENGINEERING DIVISION.

1. ENGINEERS.—Corporate Membership of the Institution of Civil Engineers, London. Commencing salaries from £895 to £1465 per annum.
2. ASSISTANT ENGINEERS.—A University Degree in Civil Engineering which gives exemption from Final Parts I and II of the A.M.I.C.E. examination or an equivalent examination. Commencing salaries from £810 to £1000 per annum.
3. ENGINEERING ASSISTANTS.—General Certificate of Education standard or equivalent and eight years' practical experience. Commencing salaries £810 to £1080 per annum.
4. DRAUGHTSMEN.—Ordinary or Higher National Certificate or equivalent and at least three years' experience at the drawing board. Commencing salary up to £1150 per annum in accordance with qualifications and experience.

MECHANICAL ENGINEERING DIVISION.

5. MECHANICAL & ELECTRICAL ENGINEERS.—Corporate Membership of the Institutions of Mechanical or Electrical Engineers, London, whichever is appropriate. Commencing salaries £895 to £1465 per annum.
6. BUILDING SERVICES ENGINEERS.—Corporate Membership of the Institution of Mechanical Engineers or of the Institution of Heating and Ventilating Engineers, London. Commencing salaries £895 to £1465 per annum.
7. ASSISTANT MECHANICAL, ELECTRICAL OR BUILDING SERVICES ENGINEERS.—A University Degree in Mechanical or Electrical Engineering or Graduate Membership of the above Institutions. Commencing salaries £810 to £1000 per annum.
8. MECHANICAL, ELECTRICAL OR BUILDING SERVICES DRAUGHTSMEN.—Ordinary or Higher National Certificate in Mechanical or Electrical Engineering or equivalent examination, and at least three years' experience in draughting, design and calculations. Commencing salaries £720 to £1000 per annum.

Inquiries, mentioning this paper and quoting reference No. 3/74/133, also stating the type and number of position sought, should be addressed to the High Commissioner for New Zealand, 415, Strand, London, W.C.2. Full details of duties, experience desired, and general information on the conditions of employment in the New Zealand Public Service, together with application forms, will then be furnished. E7820

BRITISH TRANSPORT WATERWAYS

ENGINEERING ASSISTANT

British Transport Waterways require an ENGINEERING ASSISTANT at Watford. Applicants must be Associate Members of the Institution of Civil Engineers and have had wide experience in design and construction of civil engineering works, both by contract and direct labour. Particular emphasis on hydraulics in connection with river and canal works and of structures in concrete, mass, reinforced, prestressed and steel. Experience in specification and bills of quantities is essential. Salary range: £1015–£1235, superannuation fund and certain privilege travel facilities.

Applications, stating age, experience and qualifications, to the Staff and Establishment Officer, 163, Euston Road, N.W.1, by the 21st August, 1957. E7939

AIR MINISTRY

WORKS DESIGNS BRANCH

DESIGNER DRAUGHTSMEN

Air Ministry, Works Designs Branch, requires in London, DESIGNER DRAUGHTSMEN for Bulk Petroleum Storage and Pumping Installations. experienced in one or more of the following: (a) storage tank layout and design; (b) pump house and plant layout; (c) development of pipe line schemes; (d) hydraulic calculations. Technical training to O.N.C. standard required. Salaries up to £965 per annum. Starting pay dependent on age, qualifications and experience. Long-term possibilities with promotion and pensionable prospects. 5-day week. 3 weeks' 3 days' leave a year. Normally natural born British subjects.

Write, stating age, qualifications, employment details, including type of work done, to any Employment Exchange, quoting Order No. Borough 605. E7944

BOROUGH OF POOLE

WATER UNDERTAKING

ASSISTANT PUMPING SUPERINTENDENT

Applications invited from persons not exceeding 35 years of age for the appointment of ASSISTANT PUMPING SUPERINTENDENT at the Corfe Mullen Pumping Station, Wimborne. Salary in Grade Miscellaneous V (£574 rising to £635 10s per annum), plus house, rent and rates free. Subject to Scheme for Miscellaneous Classes, Superannuation Acts and satisfactory medical examination.

Candidates should have served apprenticeship as mechanics and have a knowledge of electrical and steam pumping plant.

Application forms and further particulars from Water Engineer and Manager, Municipal Buildings, Poole. Forms to be sent to the undersigned not later than Wednesday, the 11th September, 1957.

(Signed) J. G. HILLIER,
Municipal Buildings, Town Clerk.
Poole, Dorset. E7971

PUBLIC APPOINTMENTS

CENTRAL ELECTRICITY AUTHORITY

EASTERN DIVISION

CIVIL AND STRUCTURAL DESIGNER DRAUGHTSMEN

Applications are invited for the following posts at Divisional Headquarters, Cockfosters, adjacent to Cockfosters Station (Piccadilly Line) :—

CIVIL AND STRUCTURAL DESIGNER DRAUGHTSMEN

Salary: N.J.B., Schedule "D," within the range of Grades 4/5, £800 by £20 to £945 per annum, including London Weighting.

The commencing salary will depend on experience and qualifications.

New offices recently completed in pleasant surroundings, excellent working conditions. Canteen available. Sports and social club. Sick pay and superannuation schemes. Generous holidays.

The candidates appointed will be required to undertake civil and structural design work, and applicants should have had experience in the design and detailing of reinforced concrete structures for heavy plant, culverts, &c., and structural steelwork as applied to industrial buildings.

Applications, stating age, qualifications and experience, should be sent to the Controller, Central Electricity Authority, Eastern Division, West Farm Place, Chalk Lane, Cockfosters, Barnet, Herts.

W. N. C. CLINCH,
E974 Controller.

EAST ANGLIAN REGIONAL HOSPITAL BOARD

ENGINEERS AND DRAUGHTSMEN

Applications invited from suitably qualified persons for a range of (1) mechanical and (2) electrical engineering posts for work in connection with development and design of a large new hospital and general hospital services for the whole region,

Posts are permanent and pensionable, providing scope in the entire field of hospital engineering covering surveys, reports, estimates, preparation of plans and specifications and supervision of site works undertaken by contract in connection with (1) heating, ventilating, air conditioning, boiler plant, kitchens and laundries, water supplies, &c., and (2) lighting, power, call, radio, fire alarm, telephone and clock systems, lifts, emergency supplies and electrical services in connection with (1). Hospital experience, although desirable, is not essential.

All grades of staff are required, ranging from Senior Assistants to Draughtsmen. Applications, giving full personal details of experience, qualifications, present salary, &c., with names of two referees, to Secretary of Board, 117, Chesterton Road, Cambridge, by 30th August, 1957. E7968

CENTRAL ELECTRICITY AUTHORITY

SOUTH WALES DIVISION

ASSISTANT MECHANICAL MAINTENANCE ENGINEER

Applications invited for superannuable N.J.B. appointment of ASSISTANT MECHANICAL MAINTENANCE ENGINEER, Carmarthen Bay Power Station.

Salary: K.9 £995 to £1055 per annum.

Appropriate engineering qualifications and experience in heavy plant maintenance desirable.

Application forms obtainable from Secretary, South Wales Division, Central Electricity Authority, Twyn-y-fedwen Road, Gabalfa, Cardiff, to be returned by 29th August, 1957. E7970

SOUTHERN RHODESIA PUBLIC SERVICE

CENTRAL MECHANICAL EQUIPMENT DEPARTMENT

Applications, preferably from men under the age of 45, are invited for a SENIOR PROFESSIONAL POST in the Central Mechanical Equipment Department, Salisbury, Southern Rhodesia. Salary £2550 p.a.

QUALIFICATIONS: applicants must possess a specialised Degree in Mechanical Engineering normally involving a three-year University course or be a Member or Associate Member of the Institution of Mechanical Engineers.

EXPERIENCE: considerable executive experience of management control and administration of a large repair organisation is desirable, preferably in connection with the repair of motor vehicles and heavy earth-moving equipment, and a sound knowledge of financial and budget control systems will be a recommendation.

Application forms and further details from Secretary (R), Rhodesia House, 429, Strand, London, W.C.2. Closing date August 31st. E7933

THE UNITED CAMBRIDGE HOSPITALS

ASSISTANT ENGINEER

ASSISTANT ENGINEER at the Maternity Hospital, Cambridge, to work under general supervision of the Superintendent Engineer. Whitley Council conditions and salary (i.e. £555 by £20 (1) by £25 to £675). Successful applicant will be required to reside near the hospital, and a house is available for rental, if wanted. Applications in writing, giving age, training, experience, qualifications and names of two referees, to Secretary, Addenbrooke's Hospital by 31st August. E7969

PUBLIC APPOINTMENTS

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

WINDSCALE WORKS, SELLAFIELD, CALDERBRIDGE

ENGINEERING DEVELOPMENT POSTS

Vacancies exist with the Research and Development Branch of the Industrial Group of the United Kingdom Atomic Energy Authority at Windscale Works, Sellafield, Calderbridge, Cumberland.

DUTIES :—

The posts are for ENGINEERS and EXPERIMENTAL OFFICERS, and are concerned with the development of advanced types of nuclear reactors and their associated chemical processes and include:

(a) The development of equipment and techniques for experiments in the Windscale and Calder reactors.

(b) The design and operation of experimental rigs for the study of heat transfer and associated problems connected with gas-cooled reactors.

(c) Investigations associated with liquid metal technology.

(d) The development of equipment for chemical processing of radioactive materials.

QUALIFICATIONS AND EXPERIENCE :—

Engineer Posts :—Applicants must have served a recognised engineering apprenticeship and be Corporate Members of the Institution of Mechanical or Electrical Engineers, or have equivalent qualifications.

Experimental Posts :—Applicants must possess a General Certificate of Education in at least five subjects, including two scientific or mathematical subjects at Advanced Level, or hold equivalent qualifications. The possession of a Higher National Certificate in Engineering may be an advantage.

SALARY :—Will be assessed within one of the following scales :—

Engineer III, £775 (age 25)–£1210 p.a.
Experimental Officer, £940–£1155 p.a.
Assistant Experimental Officer, £375 (at age 18)–£815 p.a.

These scales are due to be increased by approximately 5 per cent.

A contributory pension scheme is in operation.

Authority houses for renting by successful married candidates may be available in due course, or, alternatively, substantial assistance may be given towards legal expenses incurred in private purchase.

Send a postcard for an application form, quoting reference 2012, to the Recruitment Officer, United Kingdom Atomic Energy Authority, Industrial Group Headquarters, Risley, Warrington, Lancashire.

Closing date, 2nd September, 1957. E7924

BOLTON AND DISTRICT JOINT SEWERAGE BOARD

APPOINTMENT OF PRINCIPAL ASSISTANT ENGINEER

Applications are invited for this appointment at a salary within the range £1300 by £50 to £1500.

The appointment, which is not on the Board's establishment, is for a minimum period of five years, is superannuable and subject to medical examination.

Applicants must be corporate members of the Institution of Civil Engineers and a University Degree would be an advantage.

Commencing salary will be according to qualifications and experience.

The person appointed will be responsible, under the direction of the Engineer to the Board, for the design and supervision of the Board's major capital works, including a new disposal plant and large trunk sewers. Experience in this field is essential.

Application forms, obtainable from me, are to be returned by 6th September.

Please quote reference B.E. 65.

PHILIP S. RENNISON,
Clerk to the Board.
Town Hall, Bolton. E7880

SOUTHERN RHODESIA GOVERNMENT

LABOUR DEPARTMENT

VACANCY
INSPECTOR OF MACHINERY

SALARY SCALE £1220 BY £50 TO £1620 P.A.

Applicants must be qualified engineers in possession of an approved Certificate in Mechanical or Electrical Engineering or the Ministry of Transport First Class Marine Engineers' Certificate, and have had good all-round experience.

Duties will include the inspection of all classes of boilers, elevators and general machinery, and previous experience in inspection work of this kind, particularly the inspection and testing of boilers, will be a recommendation.

Application forms and further details from Secretary (R), Rhodesia House, 429, Strand, London, W.C.2. Closing date, August 31st. E7932

SURREY COUNTY COUNCIL

MECHANICAL ENGINEERING ASSISTANTS

Applications invited for following appointments:

(1) MECHANICAL ENGINEERING ASSISTANT, GRADE III £656–£784 2s. 6d. p.a. plus £30 p.a. London allowance. Should hold National Certificate and be experienced in layout and design of heating and hot water services in buildings.

(2) MECHANICAL ENGINEERING ASSISTANT, GRADE II, £609 17s. 6d.–£691 17s. 6d. p.a. plus London allowance up to £30 p.a. Preferably with some experience in layout and design of heating and hot water services in buildings.

Full details, present salary and three copies testimonials to County Architect, County Hall, Kingston, as soon as possible. E7904

Classified Advts. continued on page 4

PUBLIC APPOINTMENTS

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

RISLEY, WARRINGTON, LANCASHIRE

RESEARCH ENGINEER

A vacancy exists with the Research and Development Branch of the Industrial Group of the United Kingdom Atomic Energy Authority at its Headquarters at Risley, Warrington, Lancashire.

DUTIES :—

To lead a group of professional engineers engaged in the nuclear and thermodynamic design of irradiation rigs for use in research reactors of the Industrial Group. Close collaboration with design engineers responsible for the mechanical design and handling and servicing arrangements of the rigs is involved.

QUALIFICATIONS AND EXPERIENCE :—

Applicants must have served a recognised engineering apprenticeship and be Corporate Members of a Senior Engineering Institution, or hold equivalent qualifications. They must have a good theoretical background in engineering subjects, an adequate knowledge of physics and practical experience in plant performance testing, engineering development or design.

SALARY :—Will be assessed within the scale £1705–£1980 p.a., which is due to be increased by approximately 5 per cent.

A contributory pension scheme is in operation.

An Authority house for renting by the successful candidate, if married, may be available, or, alternatively, substantial assistance may be given towards legal expenses incurred in private purchase.

Send a postcard for an application form, quoting reference 2005, to the Recruitment Officer, United Kingdom Atomic Energy Authority, Industrial Group Headquarters, Risley, Warrington, Lancashire.

Closing date, 2nd September, 1957. E7917

CENTRAL ELECTRICITY AUTHORITY

SOUTH EASTERN DIVISION

CROYDON "B" POWER STATION

ASSISTANT CHARGE ENGINEER

Experience of operation of Power Station Plant is necessary and possession of H.N.C. preferred.

Salary, Class J, Grade 9 : £985–£1045 per annum, including London Allowance, plus 10 per cent Shift Allowance.

BRIGHTON "A" POWER STATION

ASSISTANT ENGINEER (RELIEF)

The successful applicant will have the opportunity of obtaining thorough experience in all aspects of Power Station work. Salary, Class H, Grade 14 : £635–£680 per annum, plus 10 per cent Shift Allowance when applicable.

N.J.B. Conditions of Service. Applications, giving details of education, age, present position, experience, &c., should be sent to the Station Superintendent, according to location of vacancy, at either Croydon "B" Power Station, Beddington Farm Road, Croydon, Surrey, or Brighton "A" Power Station, Portslade-by-Sea, Sussex, so as to arrive by 24th August, 1957, quoting reference (208). E7988

NATIONAL COAL BOARD

SOUTH WESTERN DIVISION

DIVISIONAL MECHANICAL ENGINEER

The National Coal Board, South Western Division, invite applications for the post of DIVISIONAL MECHANICAL ENGINEER.

Candidates should have had extensive experience in colliery mechanical plant and equipment and must be fully conversant with the design, installation, operation and maintenance of colliery surface and underground mechanical plant and machinery. They should have held previous posts requiring engineering administrative responsibility.

Salary range : £1750–£2500 per annum.

Please quote Staff Vacancy No. 370.

Applicants who applied for the previous vacancy Number 231 need not reapply.

Full particulars of age, qualifications, experience and positions held, together with details of present post and salary, should be sent to the Divisional Chief Staff Officer, National Coal Board, Cambrian Buildings, Mount Stuart Square, Cardiff, by 29th August, 1957. E7980

NIGERIAN RAILWAY CORPORATION

ASSISTANT ENGINEER

The Nigerian Railway Corporation invites applications for the following post :

ASSISTANT ENGINEER. Salary : £800 by £50 to £1600 per annum, plus £300 per annum overseas pay.

Candidates should preferably be A.M.I.C.E. or have passed Parts I and II or equivalent, and have two years' railway engineering experience or five years' experience of general construction in connection with a railway. Available on pensionable terms, or on contract with 20 per cent gratuity per annum of total pay.

Tours : 15 months' tours, followed by 15 weeks' leave in U.K. on full pay.

Allowances : In addition there are attractive allowances.

Applications to : The London Representative, Nigerian Railway Corporation, 11, Manchester Square, London, W E7986

PUBLIC APPOINTMENTS

POST OFFICE

ASSISTANT ENGINEER

At least 25 posts for men to be filled by interview. Age at least 17½ and under 23½ on 1st March, 1957, with extension for service in H.M. Forces and, up to two years, for established civil service. Candidates must have : (i) General Certificate of Education passes in English Language and four other subjects, including two at Advanced level from Pure Mathematics, Applied Mathematics, Pure and Applied Mathematics, Physics, Chemistry ; or (ii) an equivalent qualification, e.g. one based on Scottish Leaving Certificate, Scottish Universities Preliminary or Northern Ireland Senior Certificate examination ; or (iii) a Higher National Certificate in Electrical Engineering ; or (iv) a City and Guilds Final Grouped Course Certificate in Telecommunications.

Starting salary (London) : £465 at 18, 19 or 20 ; £515 at 21 ; £650 at 25 or over, rising to £950. Somewhat lower in provinces.

For particulars (including prospects) and application form, write (preferably by postcard) to Secretary, Civil Service Commission, Burlington Gardens London, W.1, quoting No. 291/57. Application forms should be returned by 12th September, 1957. E7983

COMMONWEALTH RELATIONS OFFICE

ROLLING MILL ENGINEERING EXPERT

Applications are invited by the Commonwealth Relations Office for an appointment in India as a ROLLING MILL ENGINEERING EXPERT, under the Technical Co-operation Scheme of the Colombo Plan. Will be required to act as consultant to the Steel Re-Rolling Mills Association of India to study the present state of the steel re-rolling industry, and report on the lines on which it could be improved. Must be an expert in plant layout, roll-pass design and rolling, and must be fully conversant with the rolling of small and intricate sections from billets and/or scrap. Salary, £2300 p.a., subject to U.K. income tax, plus tax-free overseas allowance of £1245 p.a. (married) or £705 p.a. (single), plus other allowances. Duration one year in the first instance. Contract with the U.K. Government.—For further information and application forms write Ministry of Labour and National Service (E.9), 26/28, King Street, London, S.W.1, quoting A12/IND/324/TCS. E7926

CENTRAL ELECTRICITY AUTHORITY

EASTERN DIVISION

SENIOR DRAUGHTSMEN (MECHANICAL)

Applications are invited for the following appointments : SENIOR DRAUGHTSMEN (Mechanical), Generation (Construction) Department at Divisional Headquarters.

Salary N.J.B., Schedule "D," Grades 4/5, £800–£1045 per annum.

The commencing salary will depend upon experience and qualifications, but will be within the above range.

Applicants must have had experience in mechanical plant layout, pipework design.

Applications, stating age, qualifications, experience and present position, should be addressed to the Controller, Central Electricity Authority, Eastern Division, West Farm Place, Chalk Lane, Cockfosters, Barnet, Herts.

W. N. C. CLINCH,
Controller.

E928

NATIONAL COAL BOARD

PRODUCTION DEPARTMENT IN LONDON

ENGINEER

ENGINEER required for superannuable post in N.C.B.'s Workshop Branch of Production Department in London, to advise on and prepare schemes for the layout of plant, equipment and services in the Board's workshops ; wide experience of such work essential. Applicants should have served an engineering apprenticeship, hold a recognised technical qualification and have had experience in the reconditioning of mining and similar types of equipment. Salary according to qualifications and experience, within inclusive range £814–£1414 (currently under review).

Write, stating age, education, qualifications and experience, to Staff Dept., National Coal Board, Hobart House, London, S.W.1, marking envelope X863/B, before 26th August, 1957. E7936

LONDON TRANSPORT

CHISWICK

PLANT ENGINEERING ASSISTANT (ELECTRICAL)

London Transport require PLANT ENGINEERING ASSISTANT (ELECTRICAL), Chiswick, for site surveys leading to final detail drawings.

Qualifications : practical knowledge of electrical equipment and installation work (lighting and power) in modern works and garages ; preparation of drawings and specifications and detailed estimates ; experience in staff control advantageous.

Salary range £790–£880. Free travel, medical examination, contributory superannuation scheme after probation.—Applications within seven days to Recruitment and Training Officer (F/EV 649), London Transport, 55, Broadway, London, S.W.1. E7995

PUBLIC APPOINTMENTS

NATIONAL COAL BOARD

NORTH EASTERN DIVISION

AREA CIVIL ENGINEER

AREA CIVIL ENGINEER required at the No. 3 (Rotherham) Area. Salary range £1250–£2000.

Applicants should have wide experience of Civil Engineering Design, contract procedure and supervision of colliery reconstruction. They should preferably be Corporate Members of the Institution of Civil Engineers.

Apply to No. 3 Area Staff Manager, Wath-on-Dearne, Near Rotherham, by 21st August, 1957. E7992

NORTH THAMES GAS BOARD
WESTMINSTER, S.W.1.

DRAUGHTSMAN

DRAUGHTSMAN required by North Thames Gas Board, in its Drawing-Office at Westminster, S.W.1. Applicants should be over 20 years of age and should have had experience in general civil engineering and the detailing of reinforced concrete structures and foundations. Possession of the Higher National Certificate would be an advantage.

Starting salary within the range £545 to £715 per annum, according to age and experience.

Applications to Staff Controller, North Thames Gas Board, 30, Kensington Church Street, W.8, quoting reference ER/358. E7948

TENDERS

NORTHUMBERLAND COUNTY COUNCIL

COUNTY SURVEYOR'S DEPARTMENT

SUPPLY OF NEW HIGHWAY PLANT

TENDERS are invited for the SUPPLY of the following items of NEW HIGHWAY PLANT :

Two No. 3/4 ton diesel Motor Wagons.
Three No. 5/6 ton diesel Motor Wagons.
Three No. Road Sprinkler Sweeper Collectors.
Three No. Self Powered Poker Vibrators.
Four No. Atkinson Gritter Spreaders.

Specifications, &c., may be obtained from the County Surveyor, Phoenix House, Queen Street, Newcastle upon Tyne, 1.

E. P. HARVEY,
Clerk of the County Council.
E7957

INDIA STORE DEPARTMENT

HEAVY-DUTY PLANING MACHINE

The Director General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of :

One No. HEAVY-DUTY PLANING MACHINE, motorised. Capacity : 4267mm. by 1219mm. by 1219mm., table 4267mm. by 914mm., speed range cutting : 6096 to 60,960mm./min., return : 33,528 to 67,056mm./min.

Tender schedules and specifications may be obtained from the above address at a fee of ten shillings, which is not refundable. The applications for Tender forms should state reference 2024/57/ENG.3.

Tenders complete with specifications are to be ubmitted by Monday, 7th October, 1957. E7953

HINDUSTAN STEEL (PRIVATE) LTD.

COAL WASHING PLANT

Hindustan Steel (Private), Ltd., c/o Ministry of Steel, Mines and Fuel (Department of Iron and Steel). Tender reference No. 11(3)–7/56, for SUPPLY and ERECTION of COAL WASHING PLANT at Dugda, in the Jharia Coalfields in Bihar.

In continuation of the advertisement dated 2–8–57, with regard to the above Tender, it may be noted that the last date for submission has been extended from 20th September, 1957, to 12th November, 1957. Tenderers should therefore submit their offers by this date. E7977

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guaranteed Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E721 z

FREE ! Brohcure giving details of Courses in Mechanical and Production Engineering, Draughtsmanship, &c. for the A.M.I.MechE., A.M.I.P.E., City and Guilds and other Professional examinations. —E.M.I. Institutes, Dept. E30, London, W.4. (Associated with H.M.V.) E972 z

WORK STUDY.—Part-time (evening) 20 weeks' Diploma Course starts September 9th. Enrolments open now.—Details of this and five other courses, including full-time (six weeks) and correspondence, from School of Time and Motion Study, 29, Cork Street, W.1. Regent 0516. E7617 z

UNIVERSITY OF MANCHESTER

The next Session commences on Thursday, 3rd. October, 1957 E7704 z

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEN COPIES, NOT ORIGINALS, OF THEIR TES MONIALS UNLESS OTHERWISE REQUESTE

A MECHANICAL ENGINEERING DRAUGHTSMAN is required by The Bahrain Petroleum Co., Ltd., 25 to 30 years of age, with minimum qualifications O.N.C. in Mechanical Engineering. Must have had at least 3 years' experience since completion of training in such work as production of original working drawings and field sketches of site alterations obtained in the drawing-office of a consultant, process design firm or jobbing maintenance organisation. The commencing salary is £1104 per annum, in addition to which free air-conditioned accommodation and local living allowance, medical attention and kit allowance are provided, with paid local and home leaves and participation in pension and provident fund plans.—Apply, in writing, quoting "ENG," with full particulars, to Caltex Services, Limited, Caltex House, Knightsbridge Green, London, S.W.1. E7984 A

A PRODUCTION ENGINEER FOR MANAGEMENT CONSULTANCY

A British firm of Management Consultants, well-established in this country and having overseas subsidiaries, has as a result of expansion, a vacancy for a Production Executive or Engineer. Applicants should be between 28 and 35 years of age and should be experienced in modern production management, shop-floor relations and work study. An honours Degree is preferred. This is an outstanding opportunity to advance quickly to a high salary level and to gain a wide experience of large sections of British industry. Starting salary is up to £1750 p.a. with progress to between £4000 and £5000 p.a. in 8 to 10 years. Movement is confined to small regions at all times and after four years' service all assignments are within daily reach of home. On the other hand, service in other parts of the U.K. or overseas, including the U.S.A., can be arranged for those who prefer it. Please communicate in strictest confidence, giving short outline of age, education, experience and salary.—BOX No. E7925, "The Engineer." A

A VACANCY EXISTS for GRADUATE MEC ANICAL ENGINEER in the Development Depa ment of Smiths Motor Accessories, Ltd. The succe ful applicant will be a man who get things done. H background must include an apprenticeship or pr tical experience, drawing-office and design experien and at least five years' development experience w light precision engineering.—Apply to Mr. D. Squire, Cricklewood Works, N.W.2 (GLA 3333). E798

AN ENGINEER, with some experience of inst mentation, is required for research projects involv components to serve at extremes of temperature a pressure in connection with the separation of ga and also with other projects involving chemical pr cesses. A man of age around 30 would be preferr but consideration will also be given to those who ha had less experience.—Apply to General Manag British Oxygen Research and Development, Lt Deer Park Road, London, S.W.19. E799

AIR-CONDITIONING ENGINEER requi to develop up this department of a Midland firm. BOX No. E1111, "The Engineer."

W. H. ALLEN SONS AND CO., LTD.,
require

(1) WORK STUDY ENGINEER, to establish a work study section at their Pershore Works. Candidates should have a sound engineering training with experience in deriving synthetic times for costing and incentive schemes.

(2) JIG AND TOOL DRAUGHTSMAN for Pershore Works, with sound engineering training and wide experience in Methods and Jig and Tool design.

Good conditions of employment with contributory pension and life assurance scheme.

Write in confidence, stating experience and qualifications, to : The Personnel Manager, Atlas Works, Pershore. E7955 A

ASSISTANT ENGINEERS are required in t Engineering Department of our Liverpool factor The work is concerned mainly with mechani engineering but extends to electrical and civil eng neering. This is a good opportunity for a you engineer interested in gaining experience in t installation and maintenance of plant. Applica should be under 35 years of age, and hold a Degree Engineering or its equivalent ; men with a High National Certificate and industrial experience will b considered.—Application form obtainable fro Personnel Manager, J. Bibby and Sons, Ltd., 5 Great Howard Street, Liverpool, 3. Please quo reference E.28. E7965

CHIEF ENGINEER required for Chemical Facto in Kent. Capable of maintenance of existing equi ment and erection and fabrication of new p Please state salary required.—BOX No. E11 "The Engineer."

CHIEF ROLL DESIGNER, aged 35–45, requi by large steel works. Applicants should be fu conversant with the designing of rolls for heavy a light mills, rolling rounds, billets, channels, angle tees, &c., in a wide range of sizes. The posi carries excellent prospects and a good salary will paid to the right man. A pension scheme and f life assurance scheme are in operation. Wr giving full details of age, qualifications and previ experience.—BOX No. E7910, "The Engineer."

SITUATIONS VACANT

BUILDING INDUSTRY
ENGINEER ESTIMATOR
Interesting position
in
NORTH WEST AREA

Fully experienced STRUCTURAL/CIVIL ENGINEER with knowledge of estimating and capable of practical design of concrete formwork. Position will entail liaison between Estimating and Construction Depts. in economic design of permanent structures and temporary works. Applicants should give all employment history and type of work undertaken, including, in confidence, present work, qualifications, education, age and approx. salary required should be included.—BOX No. E7905, "The Engineer." A

CIVIL ENGINEER required for supervision of civil engineering and building contracts in BRITISH WEST AFRICA. Applicants should be Corporate Members of the Institution of Civil Engineers and have experience of all aspects of contract administration. Generous salary and allowances.—Write, giving full details of experience, &c., to BOX E.366, c/o 191, Gresham House, E.C.2. E7962 A

CIVIL ENGINEERS for Planning Section in London office. Experience of public works construction and design essential. Salary according to qualifications. Good prospects. Pension fund.—Write details, qualifications, experience and age, to (I.A.M./6), BALFOUR BEATTY & CO., LTD., 6, Queen Street, E.C.4. E7961 A

CIVIL ENGINEERING DESIGNERS required by Westminster consulting engineers with experience in the design of one or more of the following: harbour and dock works, bridges, large dams, reinforced concrete and mass concrete structures. Salary according to experience. Five-day week, pension scheme, luncheon vouchers. Apply, stating age and experience.—BOX No. E7888, "The Engineer." A

CLEAR-THINKING ENGINEER, to work out overall planning for large contracts in the chemical and petroleum industry. Modern office accommodation, 15 miles from London. The position is permanent. Salary range £1000 to £1500 per annum. A generous pension scheme is in being.—BOX No. E1148, "The Engineer." A

COMMISSIONING ENGINEER

required, preferably with some practical experience in the operation of gas and liquid fuel-fired Industrial Furnaces of all types. A working knowledge of instruments and controls is also desirable and applicants should be prepared to travel. Salary commensurate with experience and qualifications. Pension scheme.—Apply, giving full details, to:

The Secretary,
PRIEST FURNACES LIMITED,
Longlands,
Middlesbrough,
Yorkshire. E7848 A

CONSULTING ENGINEERS have a vacancy for CIVIL ENGINEER, experienced in the exploratory work for, and subsequent design and construction of, large hydro-electric projects involving the construction of large impounding dams. Applicants must be Chartered Civil Engineers not less than 35 years old and must have several years' experience in a leading capacity as senior engineer on the investigation and construction of such projects. Salary from £1800 p.a. to £3000 p.a., according to status and experience. Applications, which will be treated as strictly confidential—BOX No. E1133, "The Engineer." A

DESIGN DRAUGHTSMEN.—The British Drug Houses, Ltd., invite applications from suitably qualified men for interesting work in the Engineers Drawing Office, on special machines and plant layouts for the Light Chemical Industry. H.N.C. in Mech. Eng. and previous experience in this industry desirable but not essential. Men of mature age with suitable training and experience, would be considered. Five-day week, pension and profit-sharing schemes.—Write, stating age, experience and salary required, to Staff Manager, Graham Street, N.1. E7871 A

DESIGNER-DRAUGHTSMEN, experienced in diesel or electric jib cranes, required. The positions offered would be permanent, progressive and pensionable for suitable applicants. Salary according to qualifications and experience. —Apply in confidence, with full details, to the Chief Designer (Cranes), Thomas Smith and Sons (Rodley), Ltd., Rodley, Leeds. E7700 A

DESIGNER/DRAUGHTSMEN, experienced in jib Cranes. &c. Position offered, due to expansion of firm's activities, would be permanent, progressive, and would carry salaries commensurate with experience. Pension scheme.—Apply: Chief Engineer, Clyde Crane and Engineering Co., Mossend, Nr. Motherwell. E7874 A

DESIGNER-DRAUGHTSMAN, with experience water-tube boilers, required for newly forming company, south of London. Good prospects and salary. —BOX No. E1080, "The Engineer." A

DESIGNER-DRAUGHTSMEN & DETAILERS wanted for work on chemical plant layout, vessel design and pipework, &c. Top salaries offered men with experience and maximum assistance in regard to housing. Grant towards removal expenses and living allowance until removal completed. Pension and insurance scheme, technical library, sports ground.—Apply, "ref. D," Staff Personnel Manager, Power Gas Corpn., Ltd., Stockton-on-Tees. E7738 A

DRAUGHTSMAN (Senior) having experience in machine design and works layouts. A knowledge of works building design desirable but not essential. Technical education to at least O.N.C. standard. DRAUGHTSMAN (Junior) for General Engineering Design or Jig and Tool Design.—Applicants are invited to submit full details of age, experience and salary required, to the Personnel Manager, Ferodo Limited, Chapel-en-le-Frith, Via Stockport. E7963 A

SITUATIONS VACANT

DRAUGHTSMAN.—Arthur Guinness Son and Co. (Park Royal), Ltd., have a vacancy on their permanent staff for an Engineering Draughtsman. Applicants, aged 25/30 years, should have at least a National Certificate in Mechanical Engineering together with works and drawing-office training. Experience in design and detail work in some of the following fields is essential: Chemical and Process Plants, Layouts and Services, Refrigeration Plant, Mechanical Handling and General Mechanical Engineering. The company provides a non-contributory pension scheme and excellent amenities. Commencing salary range is £700/£925, depending upon age and experience.—Applications, stating age, particulars of experience, &c., should be sent in confidence to the Personnel Manager, Arthur Guinness Son and Co. (Park Royal), Ltd., Park Royal Brewery, London, N.W.10. E7850 A

DRAUGHTSMEN required in the following categories: Senior and Junior Piping and Instrumentation; Senior and Junior Reinforced Concrete; Senior Mechanical, by engineers in City engaged on nuclear, petroleum, chemical plants. H.N.C./O.N.C. desirable. Salaries above average, five-day week, pension/life assurance and personal accident schemes, house purchase assistance, luncheon vouchers.—Write full particulars to Head Wrightson Processes, Ltd., 24/26, Baltic Street. E.C.1. E954 A

EDWARDS HIGH VACUUM, LIMITED, Manor Royal, Crawley, Sussex, have a vacancy for a LOW-TEMPERATURE RESEARCH ASSISTANT (Degree or equivalent, in Mechanical Engineering, Chemical Engineering or Physics), for apparatus development. Experience in vacuum and/or handling of liquefied gases an advantage. Development aptitude and associated skills essential. Commencing salary offered is commensurate with age, qualifications and experience. Housing available if from London area. Pensionable position.—Write, giving details to Personnel Manager. E1149 A

ELECTRICAL DESIGNER sought by established manufacturers, in London, with world market for special-purpose precision machinery. Exceptional prospects for qualified electrical engineer having practical experience, aged 30-40, who is possessed of the "creative spark." Only applicant fertile in ideas, with original and inventive mind and receiving recognition in his present post on this account, need apply.—Write in confidence, Personnel Manager, Molins Machine Co., Ltd., Evelyn Street, London, S.E.8. E7882 A

ELECTRICAL ENGINEERING DRAUGHTSMAN required, with some experience in the preparation of schemes for M.V. electrical distribution and illumination and electrical equipment of industrial buildings. Minimum technical qualification O.N.C.

Minimum starting salary for draughtsmen of H.N.C. standard is £747 p.a. at 25. Salary reviewed annually. Conditions include a contributory pension scheme, assistance with house purchase, family education schemes, a wide variety of recreational facilities, &c.

Apply, stating age, qualifications and experience, to the Personnel Officer, PILKINGTON BROTHERS, LIMITED, Cowley Hill Works, St. Helens, Lancashire. E7881 A

ELECTRICAL/MECHANICAL ENGINEERING DESIGNER

This senior position with Merseyside company of medium size calls for rotating machine design ability, both electrical and mechanical, of a high order. Experience on control gear and systems, including electronics, is equally desirable.

The company, associated with a large group, expects to pay an attractive four-figure salary to a top-flight Designer who is looking for a challenging position in which he can both develop and extend the company's existing range of products. These products are of small/medium size and special-purpose type.

First-class qualifications are necessary; adequate benefits are available. Applications, which should include age and salary indication, will be treated most confidentially.—BOX No. E7920, "The Engineer." A

ENGINEERING INSURANCE COMPANY invites applications from Engineers not over 35 years of age who possess First Cless M.O.T. Certificate (Steam) for position as ENGINEER SURVEYOR in London and surrounding districts. Progressive salary scale rising to over £1000 per annum plus expenses and allowances. Non-contributory pension scheme and other staff schemes. Apply in own handwriting.—BOX No. E7903, "The Engineer." A

ENGINEERING SALES MANAGER.—Exceptional opportunity with London concern having interests in every branch of engineering and science. Sound, practical and technical training, experience in sales promotion and management and ability to organise, are essential. Attractive salary and conditions. Age 30-50.—BOX No. E7923, "The Engineer." A

ENGINEER.—INSTRUMENT ENGINEER required for a new division of a large light engineering company, S.W. London. Applicants must have an Engineering qualification to B.Sc. standard, with previous experience in the field of advanced instrumentation and the application thereof. Duties will involve contact at senior levels, including designers, with a view to advising on design and application of instruments to atomic energy prospects. Please apply, stating full details of previous experience, age and salary required, to Personnel Manager.—BOX No. E7994, "The Engineer." A

ENGINEER REPRESENTATIVE, basic mechanical engineering background and commercial experience desirable. High and low-pressure pipework fabrication and installation, medium heavy forgings. required for North-West area, with occasional visits to Midlands. Applicant would be required to be based in Manchester area. State age, experience and salary required.—BOX No. E1142, "The Engineer."

SITUATIONS VACANT

ENGINEER SURVEYOR for Inspection of Cranes and other Lifting Plant required. East Midlands and South Wales areas. Must have drawing-office experience of design of cranes, also National Certificate for Mechanical Engineering. Salary: £735 to £1060 (E.S.A. Scale). Non-contributory pension, &c.—Apply, Manager, Engineering Dept., General Accident Corp.. Ltd., 99, Aldwych, London, W.C.2. E7967 A

ENGINEER SURVEYOR required immediately for medium-size road and sewer contracts in London area. Good prospects for young man.—Write in confidence, the Secretary, Fitzpatrick and Son (Contractors), Ltd., 455, Old Ford Road, Bow, London, E.3, stating age, experience, salary required, &c. E1129 A

ENGINEERS with specialised training in the design and execution of prestressed concrete projects are required for permanent employment in Rhodesia and the Union of South Africa. Free passages, pension scheme, excellent prospects.—Full details to BOX JY/29, c/o 95, Bishospgate .London, E.C.2. E973 A

ENGINEERS (MECHANICAL), Senior and Junior, required by large modern Producers of Man-made Fibres in North West, to work on erection of new plant, modifications of existing plant and maintenance. Seniors should be Corporate Members of Institution and/or have Degree. Juniors should have H.N.C., plus suitable experience, but training will be given to equip for more senior positions. Chemical experience an advantage in both cases but not essential. These posts are permanent and progressive for suitable applicants. Good salaries, pension scheme and assistance with housing. Age range between 27 and 45 years preferred.—Applications, in confidence, should state age, qualifications, experience, in sequence, and be addressed to Personnel Manager, British Enka Limited, Aintree, Liverpool, 9. E7937 A

EXPERIENCED CHIEF DRAUGHTSMAN required, for small mechanical and chemical engineering drawing-office of growing Anglo-American company in Camberley. Previous experience in drawing-office organisation essential, with sound grounding in mechanical engineering. Dynamic and enthusiastic approach to problems essential. Permanent and pensionable appointment.—Apply to GPB. Sharples Centrifuges, Limited, Tower Works, Doman Road, Camberley, Surrey. E7772 A

EXPERIENCED ESTIMATORS required for Engineering Works for the preparation of labour and material estimates in connection with Iron and Steel Works Plant, including Rolling Mills and their auxiliaries. Persons accustomed to taking responsibility and able to work from prepared schemes and with sound experience in general engineering. Excellent prospects and salary paid to the right personnel. Superannuation scheme in operation.—State full details of experience to B. THORNTON, LTD., Engineers, Huddersfield. E7938 A

FIVE MINING ENGINEERS required by the Schwager Company, a large coal mining company at Coronel, Chile, with output of approximately one million tons annually. One to act as Chief of the Planning Department and the other four in more junior and general production capacities. Successful applicants must have University Degree and Colliery Manager's Certificate. Contract and good pension scheme.—Apply in writing, stating age, qualifications, experience and salary required, to Managing Director, Powell Duffryn Technical Services, Limited, 19, Berkeley Street, W.1, marked "Schwager." E7612 A

FULLY-QUALIFIED MECHANICAL ENGINEERING DRAUGHTSMAN required for Chemical Works. Experience in design of chemical plant or similar equipment preferred but not essential. Staff pension scheme in operation.
Good salary will be offered to suitable applicant. Apply, stating age, qualifications and experience, to Employment Manager, The Washington Chemical Co., Ltd., Washington, Co. Durham. E1134 A

G.E.C.–SIMON-CARVES ATOMIC ENERGY GROUP
have vacancies for
ENGINEERS

interested in theoretical or experimental structural and stress analysis for design and development work on reactor pressure vessels and complex steel structures.

Previous experience is desirable but not essential.

These posts offer excellent opportunities for imaginative young men under 28 years of age who are anxious to join a rapidly expanding organisation in a new and important branch of engineering. The positions are suitable for University Graduates with or without an Honours Degree and in some cases for candidates with a National Certificate.

Apply, giving age and particulars of training and experience, to Personnel Manager (K.J.W.), The General Electric Company Limited, Fraser and Chalmers Engineering Works, Erith, Kent. E7960 A

GRADUATE ENGINEERS

Henry Wiggin and Co., Ltd., makers of high-nickel-containing alloys, are expanding their Technical Service Section and require the services of several Engineers.

Preference will be given to men who have considerable industrial experience, particularly in the field of High Temperature Engineering.—Applications should be addressed to the Director and Sales Manager, Henry Wiggin and Co., Limited, Wiggin Street, Birmingham, 16. E7921 A

FOREMAN PLATELAYER required for laying new and maintaining existing railway track at large steel works in the Midlands. Staff position, pension scheme, free life assurance, &c. Write, giving details of age and experience.—BOX No. E7908, "The Engineer." A

SITUATIONS VACANT

HEAT TRANSFER AND FLUID FLOW.— RESEARCH AND DEVELOPMENT ENGINEER required by an old-established engineering company in the Glasgow area. Applicants, aged 25-30, should have a University Honours Degree in Engineering and some research experience. The work would involve the theoretical design and practical testing of new types of heat exchanger. A good salary would be paid to an applicant with the necessary qualifications. Apply, giving age and full particulars.—BOX No. E788, "The Engineer." A

INSTRUMENT ENGINEER required by The British Drug Houses, Ltd., to control small section in Engineering Department. Applicants must be capable of planning instrumentation of production plants and estimating, be experienced in maintenance, installation and design, and have H.N.C. Mech. Eng. or equivalent.—Write, stating age, qualifications, experience and salary required, to Staff Manager, Graham Street, City Road, N.1. E7872 A

JACKSON BROS. (OF KNOTTINGLEY), LTD., require ENGINEERING ASSISTANTS for maintenance and development work in a modern Glass Container Works. The posts are permanent and pensionable, and offer scope for further training and advancement. Previous experience in glass-works not essential. Successful applicants must have served an engineering apprenticeship, must be either A.Grad.I.Mech.E., or studying for this qualification, and have had some experience in general works maintenance. Experience in modern machine shop practice is an advantage. Salary will be according to qualifications and experience.—Applications to the Personnel Officer, Messrs. Jackson Bros. of Knottingley, Ltd., P.O. Box No. 2. E1136 A

KUWAIT OIL COMPANY
requires
ASSISTANT PETROLEUM ENGINEERS
for service in KUWAIT

The Company has vacancies for Assistant Petroleum Engineers. Candidates, who should be between 21 and 30 years of age, must be University Graduates in Petroleum Engineering or Oil Technology, or in Physics or Geology. Prior experience in petroleum engineering, production or laboratory work is desirable, but not essential.

Salary will be according to qualifications and experience, but total pay, including local currency allowance, will be not less than £1700 p.a. An initial kit allowance is payable and there is a pension scheme.

Write for application form, giving brief details, and quoting K.2310, to BOX V/49, c/o 191, Gresham House, E.C.2. E7981 A

KUWAIT OIL COMPANY
requires
ASSISTANT ENGINEER
for service in their London Office

The Company has a vacancy in the Refinery Department of their London Office for an Assistant Engineer for work of technical administration. Candidates must hold a University Degree in Mechanical or Chemical Engineering. They must have sound knowledge of engineering materials, specifications and practices of the petroleum industry, and must have had practical experience in this field of work. They should be between 25 and 35 years of age, and prepared to undertake visits overseas.

Salary according to experience, but not less than £1200 p.a. Lunch vouchers are supplied, and there is a non-contributory pension scheme.

Write for application form, giving brief details and quoting L.O.243, to BOX V/181, c/o 191, Gresham House, E.C.2. E7982 A

MANAGEMENT SELECTION, LIMITED,
have been retained to advise on the appointment
of a

WORKS MANAGER

to take complete charge of a light engineering works in the Midlands employing approximately 1,000. The factory is a member of a large engineering group and the management has recently embarked on a major re-organisation and modernisation.

The Works Manager will be responsible for all aspects of manufacture covering mainly bar autos, lathes, grinding machines, special purpose cold forging equipment, heat treatment, &c., and for tool room, production planning and control, and stores. He will be expected to take an active interest in the modernisation scheme now being implemented.

Applicants, who should be qualified mechanical or production engineers, must have had experience of modern machine shop practice and control methods and have had several years' experience of works management with a successful record of negotiating with trade unions, &c.

Preferred age 35-40. Initial salary in the £1750–£2300 bracket. Car provided. There is a good non-contributory pension scheme and the company is prepared to assist with removal expenses.

Please send brief details in confidence, quoting reference G.537, to M. B. Berks, Management Selection, Limited, 17, Stratton Street, London, W.1. No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. E7942 A

Classified Advts. continued on page 6

SITUATIONS VACANT

MAKE REFRIGERATION YOUR CAREER.—SEVERAL SALES APPLICATIONAL ENGINEERS required urgently for industrial size equipment. Minimum qualifications H.N.C. Splendid opportunities for keen men. May be stationed in London or provinces. Reply, giving details age, experience, salary.—BOX No. E1139, " The Engineer." A

MECHANICAL ENGINEER required by Smiths Motor Accessories, Ltd., H.N.C. standard and at least 5 years' practical experience in light engineering, preferably instrument testing.—Apply to Mr. D. H. Squire, Cricklewood Works, N.W.2 (GLA 3333). E7990 A

MEGATOR PUMPS AND COMPRESSORS, LTD., require ENGINEER to handle technical sales correspondence and tenders in their LONDON OFFICE. Previous experience in similar capacity, particularly on marine side, an advantage.—Write, stating age, qualifications and experience, to Sales Director, 43, Berkeley Square, London, W.1. E7951 A

MUNICIPAL MUTUAL INSURANCE, LIMITED, has vacancies for ENGINEER SURVEYORS in London, Birmingham, Sheffield and Nottingham. Posts are pensionable and permanent to satisfactory candidates, who should have served an apprenticeship and have sound practical and theoretical knowledge. Technical qualifications : First Class Ministry of Transport Certificate. Salary, £675–£1000 per annum.—Apply in own handwriting, marking the envelope " Application Engineer Surveyor " and " Private and Confidential," to the Chief Engineer, Old Queen Street, Westminster, S.W.1. E7950 A

PARTS MANAGER for established British company in Baghdad, handling heavy earthmoving equipment and contractors' plant. Must be experienced in inventory control and Kardex system, trained in accountancy, technical background essential. Salary up to £3000 p.a., according to qualifications, accommodation provided. Two-year contract and four months' home leave.—Apply, stating experience and qualifications, to BOX No. 623, c/o Dawsons, 129, Cannon Street, E.C.4. E7959 A

PHILIPS ELECTRICAL INDUSTRIES PTY., LTD.,
AUSTRALIA

large manufacturer and distributor of receiving valves, cathode-ray tubes and other electronic components, requires a
SALES ENGINEER
not over 35 years of age, to promote the sale of its products throughout the Australian Commonwealth.

Applicants should have a Degree, preferably in Electrical Engineering, or equivalent qualification, and a substantial knowledge of the application of valves, picture tubes and other components in the design and manufacture of television receivers and other electronic apparatus, together with some years of practical experience in this field.

The salary will be commensurate with age, experience and qualifications.—Applications, marked 2KI/SE, should be addressed to BOX E 227, L.P.E., Romano House, 339/401, Strand, W.C.2. E7946 A

PHILIPS ELECTRICAL INDUSTRIES PTY., LTD.,
AUSTRALIA

large manufacturer and distributor of receiving valves, cathode-ray tubes and other electronic components, requires an
ENGINEER
not over 35 years of age, for its Engineering Applications Laboratory in Sydney, New South Wales.

Applicants should have a Degree, preferably in Electrical Engineering, or equivalent qualification, and a substantial knowledge of the application of valves, picture tubes and other components in the design and manufacture of elevision receivers and other electronic apparatus, together with some years of practical experience in this field.

The salary will be commensurate with age, experience and qualifications.—Applications, marked 2KI/EA, should be addressed to BOX E 226, L.P.E., Romano House, 399/401, Strand, W.C.2. E7945 A

PILKINGTON BROTHERS, LIMITED, invite applications for a position in the estimating section of a medium-sized drawing-office. The work covered by this section includes :—

1. The preparation of approximate estimates for buildings and plant from brief specifications and/or arrangement drawings.
2. Preparation of estimates for capital sanction from final arrangement and detail drawings. This work requires an intimate knowledge of the mechanical engineering trades and practices.
3. Valuation of plant and buildings for asset verification and fire insurance purposes.

Applicants should have some experience in one or more of these fields and should be qualified to O.N.C. standard.

Minimum starting salary for applicants having suitable experience and qualifications is £721 p.a. at 25.

The company operates a contributory pension scheme, assists with house purchase and has excellent canteen, welfare and recreation facilities.

Applications, giving brief details of career, should be sent to the Chief Engineer, Pilkington Brothers, Limited, Cowley Hill Works, St. Helens. E7883 A

PETER LIND & CO., LTD., Romney House, Tufton Street, Westminster, S.W.1, have vacancies for fully qualified SITE ENGINEERS for civil engineering contracts.—Apply in writing only, stating age, experience and salary required. E7887 A

SITUATIONS VACANT

PLANT AND MATERIALS MAN required by leading constructional engineers for its Inner London offices. Responsibility includes purchase and movement of heavy plant and equipment, also keeping of full records. Experience should cover site stores control within a good general engineering background.—Write fully, stating age and when available, to BOX No. 1080, c/o Charles Barker and Sons, Ltd., Gateway House, London, E.C.4. E7985 A

POWER-HOUSE SUPERINTENDENT required by the Baghdad Electricity Services for steam power station, medium pressure, 41MW installed capacity, Babcock boilers and Parsons turbo-alternators. Three years' initial contract, three months' leave after twenty-four months in Iraq. First-class passage paid for successful applicant and family. Salary Iraqi Dinars 170 per month, plus high cost-of-living allowance ID.22 to 25, according to number in family. Free house and heavy furniture provided. Age 35 to 45 years. Provident fund exists. —BOX No. E7991, " The Engineer." A

QUALIFIED CIVIL ENGINEER required by consulting engineers, with experience in design of quays and other maritime structures in reinforced concrete. Good salary according to qualifications and experience. Five-day week and bonus.—Apply, giving full particulars, to T. F. Burns and Partners, 25, Victoria Street, S.W.1. E1147 A

REFRIGERATION. — Qualified ENGINEERS, Senior and Junior, for interesting and varied industrial sales engineering work. Excellent prospects for energetic men with or without previous experience and holding H.N.C. or better.—Full details age, experience, salary, to York Shipley, Ltd., North Circular Road, London, N.W.2. E1140 A

REQUIRED for one of the London factories in the Crosse and Blackwell Group, BOILER HOUSE AND SERVICES ENGINEER with ability to branch out, under guidance, on special investigations for maintenance in all its aspects and the implementation of preventive measures for newly-developed processing equipment. Previous experience in a food factory not essential.—Applications to the Secretary, Crosse and Blackwell Limited, 20, Soho Square, London, W.1. E7964 A

RESIDENT ENGINEER required for large Wharf Reconstruction Scheme in North Lancashire, involving reinforced concrete construction and anchored steel sheet piled walls. Applicants for this post must be Corporate Members of the Institution of Structural or Civil Engineers and have held a responsible position on site works. Salary will be fixed according to qualifications and experience.—Applicants are invited to write in confidence to Considere Constructions Limited, 72, Victoria Street, London, S.W.1, stating age, professional qualifications and full details of experience, together with the names of two referees. E1144 A

SALES ENGINEER required by a large Merchant House in British West Africa for their Engineering Department. Practical engineering experience desirable. Remuneration will be between £1300 and £1500 p.a., depending on qualifications and experience. Family allowances, pension fund, free furnished quarters in Africa and free passages. Please write, giving full details.—BOX No. E7956, " The Engineer." A

SALES ENGINEER required for the London office of a leading firm of pump and compressor manufacturers. Applicants should have a sound knowledge of pumps and/or compressors and their application, and should be used to estimating. Good salary and prospects for suitable applicant. Apply in confidence, stating age and experience.—BOX No. E1089, " The Engineer." A

SENIOR DRAUGHTSMAN required for steel works in the Midlands area. Experience in steel works practice desirable but not essential. Good conditions and prospects and permanent situation offered to suitable applicant. Pension scheme and free life assurance scheme and canteen facilities. Excellent salary range. Apply, giving age and experience.—BOX No. E7907, " The Engineer." A

SENIOR MECHANICAL DESIGN DRAUGHTSMEN are invited to join a progressive design team engaged on varied and interesting work in the compressed air industry.—Write, or 'phone, details of experience, salary required, &c., to the Chief Draughtsman, Air Pumps, Ltd., Bushey Road, London, S.W.20 (WIMbledon 9441). E7929 A

SMITHS MOTOR ACCESSORIES, LTD.,
require

SENIOR DRAUGHTSMAN—for production drawing-office, with experience of instruments or small mechanisms, at least O.N.C. standard. Knowledge of press work an advantage.

DRAUGHTSMAN—Checker, over 30. Preferably used to instrument or precision work.

JIG AND TOOL DRAUGHTSMAN—with some machine shop and tool room experience.

PLANT LAYOUT DRAUGHTSMAN—O.N.C. or equivalent, with experience of minor building alterations ; layout of machine tools.

QUALITY CONTROL ASSISTANT ENGINEER—O.N.C. (Mech.), experience of instruments or small mechanisms, to ascertain causes of developed faults.

METHODS ENGINEER—sound mechanical background with some knowledge of assembly procedure and layout.

STANDARDS ASSISTANT — preferably young man studying for O.N.C., to handle costing and standardisation of proprietory components for light engineering ; allied to purchasing.

TECHNICAL CLERK—some engineering background, be able to read engineering drawings and write good English.

Apply to Mr. D. H. Squire, Cricklewood Works, N.W.2 (GLA 3333). E7987 A

STEEL WORKS ASSISTANT ENGINEER required by a large Midlands steel works to supervise the maintenance of a modern open-hearth melting shop and associated waste heat boiler installation. Applicants should be of Higher National Certificate standard or equivalent and have experience of modern steel works maintenance. This is a staff position with a pension scheme and free life assurance. Write, giving full details of age, experience and remunerations required.—BOX No. E7909, " The Engineer."

SITUATIONS VACANT

SPERRY GYROSCOPE CO., LTD.,

require ENGINEERS to work on development of precision instrumentation associated with Guided Weapon Control systems. Posts based at Brentford and Stonehouse (Glos.) and applicants must later be prepared to move to Bracknell where new premises are being constructed, and where housing will be available in approved cases. Vacancies as follows :—

ENVIRONMENTAL ENGINEER (Brentford) with experience in precision instrument or G.W. testing to conduct vibration, shock, g, climatic testing and later advise on design for reliability.

ELECTRONIC ENGINEER (Brentford) to develop servo circuitry using transistors, and investigate problems of temperature control and precision power supplies.

ELECTRONIC ENGINEER (Stonehouse) initially to develop electro-mechanical integrators and associated servos for an analogue computer. Mathematical knowledge of servos required.

ELECTRO-MECHANICAL ENGINEERS (Brentford) for servo development. Physics background of precision measurements would be helpful.

MECHANICAL ENGINEER (Brentford) with theoretical thermo-dynamics background for missile temperature control problems in addition to development of mechanical components. Interest in fields akin to chemical process control might be appropriate.

A degree or equivalent and sound experience is required for the above posts. Good commencing salaries will be paid with good prospects of advancement depending on merit. Pension scheme, &c.

Applicants should write to R. W. H. Lubbock (Ref. E.247), Sperry Gyroscope Co., Ltd., Great West Road, Brentford, Middlesex. E7954 A

TECHNICAL WRITER required by rapidly expanding engineering company of international repute in Luton, Beds, for sales promotion duties concerned primarily with the preparation of publications ranging from technical data sheets to brochures. The job offers considerable interest and scope for initiative, since the subjects cover all branches of engineering. Applicants should have good general engineering experience and preferably hold H.N.C. Ability to write good English essential. Apply, giving full particulars.—BOX No. E7940, " The Engineer." A

THE ALUMINIUM DIVISION OF TUBE INVESTMENTS, LTD., require ENGINEERS for interesting development work. Honours Graduates preferred with structural and strength of materials background ; age about 30. Excellent prospects for men with initiative. Salary according to qualifications and experience.—Applications should be addressed to Development Manager, T.I. Aluminium, Ltd., 10, Buckingham Place, London, S.W.1. E7958 A

THE NESTLE CO., LTD., require a MACHINE TOOL ENGINEER, to be responsible for tinshop quality control, tool and precision machine maintenance in their Northern Irish manufacturing centres. All applicants must have had practical experience and served an approved apprenticeship. Prior tinshop experience an advantage, but not essential, as a familiarisation period on this type of plant can be arranged. Age limit 30–35. The post carries staff status and salary would be according to experience. Excellent pension scheme and housing provided.—Applications to The Nestle Co., Ltd. Production Division, Hayes, Middlesex (ref. IHC). E7722 A

THE REED PAPER GROUP
have a vacancy at
COLTHROP BOARD AND PAPER MILLS,
THATCHAM, BERKS,
for a
CHIEF DRAUGHTSMAN

to control a drawing-office of 18 covering the engineering work of a large Board and Paper Mills. At least Higher National Certificate in Mechanical Engineering is required, and candidates must have had experience of paper or board mill engineering and be capable in all aspects of drawing-office administration. Salary and conditions of service are excellent. Assistance is offered with housing and the pension fund is non-contributory.

Applicants should write, giving full details of qualifications and experience, to the Personnel Officer, Group Personnel Division, Albert E. Reed and Co., Ltd., Larkfield, Nr. Maidstone, Kent, quoting Ref. 49/C. E7664 A

THE SUPERHEATER COMPANY LIMITED,
53, HAYMARKET, LONDON,
S.W.1.

SENIOR AND JUNIOR DRAUGHTSMEN required for Power Plant Division at their London Office. Experience in steam boiler plant an advantage but not essential. Permanent and pensionable positions offering good prospects for suitable applicants.—Applications are invited to the Secretary, giving full details of qualifications and experience. E7865 A

JOHN I. THORNYCROFT AND CO., LIMITED, require a DEPUTY INSPECTION CONTROLLER, with initiative and organising ability, to work in Southampton, covering quality control of the production of marine steam and gas turbine propulsion machinery. Candidates, aged 28–40, should be Chartered Mechanical or Marine Engineers, or be similarly qualified, and should have held a responsible position in the production or repair of marine or medium/heavy machinery.—Apply in writing, giving details of education, qualifications and previous experience, to John I. Thornycroft and Co., Ltd., Woolston Works, Southampton. E1137 A

SITUATIONS VACANT

WANTED

CHIEF ENGINEER for Iron and Steel Works in North West England. The post entails the maintenance and development of plant comprising coke ovens, blast furnaces, rolling mills, power station, mines and quarries.

Applications to :—

Secretary,
Workington Iron & Steel Company,
Moss Bay,
Workington. E1143 A

WORKS ENGINEER

(with prospects of a Board appointment)

An important company in the North of England concerned with manufacture in the woodworking industry, invites applications from qualified mechanical engineers for the appointment of a Works Engineer, to be responsible to the Managing Director for all engineering, other than production, and would be required to manage and co-ordinate the services, maintenance and other engineering functions of the company.

Previous experience in the woodworking industry would be an advantage, but it is not essential. Qualifications should include A.M.I. Mech.E., and good general mechanical experience with evidence of organisation and managerial ability.

Age range 33/50. Salary £2000–£3000 (approx.)

Full particulars, stating age, qualifications, experience and degree of responsibility, to :

The Secretary,
THE PROFESSIONAL ENGINEERS
APPOINTMENTS BUREAU,
9, Victoria Street,
London, S.W.1. E7979 A

WORKS MANAGER, to take complete control manufacture of medium-sized electrical rotatin equipment. Applicants (30/45) should be well verse with modern manufacturing processes, have driv enthusiasm and preferably experience in manufactu of electrical apparatus. Write in confidence, givi full details of experience, salary required and age. BOX No. E1127, " The Engineer."

WORLD-WIDE MANUFACTURERS polishes with London Headquarters require two m to train as MANAGER and ASSISTANT for fa tories in South America. The following qualific tions are essential. Fluent Spanish, experience factory administration, age 30–40. A knowledge tin box making and previous residence in Sou America are desirable. Periodic home leave a membership of pension scheme. Salary by arrang ment. Apply, giving brief particulars of qualific tions and experience.—BOX No. E7941, "T Engineer."

CONSULTING ENGINEERS

Consulting Engineers, representing a number of Specialist Continental Machine Tool Makers in the U.K., seek REGIONAL SUB-AGENTS.

We are concerned with the supply of semi or fully automatic plant, often tailor-made for the customer's production. Also with special-purpose lathes, transfer presses, automatic welding plant, &c., and our machines have gone into works in this country on a fairly large scale.

We have in mind engineers capable of originating enquiries and discussing projects with Works Planning Departments, with our effective support.

We are an international organisation and working with us affords considerable scope, though very little peace.—BOX No. E1135, " The Engineer." A

SENIOR DRAUGHTSMAN

required, experienced in heavy machinery plant layout and material handling ; first-class man only.

This is an opportunity to join small team in large organisation, offering regular employment with good salary, pension fund and profit-sharing bonus.

Reply, giving full particulars of experience, age, &c., to

The Chief Engineer,
THE ASSOCIATED PORTLAND
CEMENT MANUFACTURERS LTD.,
Portland House, Tothill Street, London, S.W.1
E7855 A

SITUATIONS VACANT

PAMETRADA RESEARCH STATION, WALLSEND

requires a

DEPUTY DIRECTOR (DESIGN)

The position is a very highly responsible one and offers very real scope for the development of marine turbine designs. Applicants should have a University Degree in Mechanical Engineering and have had wide experience in the design and manufacture of steam turbines operating under high inlet conditions, and also have held a responsible Design Office position. A knowledge of gas turbine design and construction is an additional advantage. Applicants should be aged between 35 and 45, although some departure at the upper end of the scale will be considered if all other requirements are satisfactory. The position is permanent and pensionable. The salary offered will be in the region of £3500 according to qualifications. —Applicants should send full particulars of qualifications, experience, &c., to the Director. Pametrada Research Station. Wallsend Northumberland. Replies will be treated in the strictest confidence. E7922 A

SITUATIONS VACANT

SENIOR ENGINEERS

and

DESIGNER-DRAUGHTSMEN

are cordially invited to contact KELLOGG INTERNATIONAL CORPORATION, leading Design and Construction Engineers of world-wide repute in the petroleum and chemical industries who have immediate vacancies in their new additional premises where a great expansion programme is providing excellent opportunities. Do you know about the very comprehensive personnel benefits and happy working conditions ? Write to the Personnel Manager, Kellogg International Corporation, 7–10, Chandos Street, London, W.1, or Telephone MUS 4010. E7947 A

SITUATIONS VACANT

ENGLISH ELECTRIC COMPANY LIMITED

GUIDED WEAPONS DIVISION

LUTON STEVENAGE

DESIGNER

A vacancy exists in the Mechanical Engineering Department for an Electro-Mechanical Designer to work on Ground Equipment of Guided Weapon Projects.

Applicants should be capable of doing straightforward circuit design and have had experience of associated mechanical engineering design work and installation problems. Candidates should have reached H.N.C. in Electrical Engineering.

Housing may be made available to the successful applicant. Please reply to Dept. C.P.S., 336/7, Strand, London, W.C.2, quoting Ref. ER 1396B. E7931 A

BABCOCK & WILCOX, LTD.

Atomic Energy Department

SENIOR AND JUNIOR ENGINEERS

required for
design work on
Special Pressure Vessels
and
General Stress Analysis Problems
in connection with important Nuclear Projects.
and Contracts for British and Overseas clients.

Write, giving details of qualifications and experience, to :

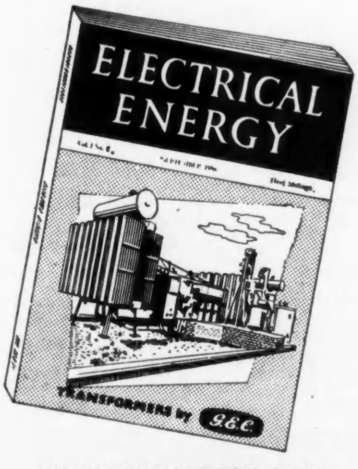
The Chief Engineer and Manager,
BABCOCK & WILCOX, LTD.,
Atomic Energy Department,
209, Euston Road,
London, N.W.1.

E7952 A

BOOKS and PUBLICATIONS

FOR THE ADVANCEMENT OF ELECTRICAL SCIENCE...

ELECTRICAL ENERGY is a monthly technical journal for Electrical Engineers having a scientific turn of mind. Its articles are designed to bridge the gulf between research and its practical application. Bringing up-to-date information about new theories, methods and materials, it is of inestimable value to electrical designers.



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Proprietors of "THE ENGINEER" and "ELECTRONIC ENGINEERING"

ONTARIO HYDRO

One of Canada's most progressive publicly-owned utilities
requires

MECHANICAL DRAUGHTSMEN

Applications are invited from Mechanical Draughtsmen who are contemplating emigrating to Canada and who possess the following qualifications :—

Experience in steam generation or industrial process piping is essential. Able to prepare intricate high-pressure piping and major mechanical equipment drawings for construction purposes. Layout and detail drawings for water services, including fire protection, sewage disposal and surface drainage and also generating station substructure embedded piping.

Experience need not cover the full range indicated.

All positions are pensionable and carry an attractive health and insurance scheme. Special sick leave plan and vacations with full pay.

Salaries on Canadian scale and commensurate with experience and qualifications.

Write to Ontario Department of Immigration, 25, New Burlington Street, London, W.1, for application form. E966 A

STEWARTS AND LLOYDS LIMITED

OF CORBY, NORTHAMPTONSHIRE

have a few vacancies for

SENIOR DRAUGHTSMEN & PLANT DESIGNERS

These vacancies occur in a New Development Department of this large integrated Iron, Steel and Steel Tube Works. Applicants should possess Higher National Certificates but those with Ordinary National Certificates will be considered if they have reasonable experience in design. Corby is a New Town and housing conditions are favourable; Staff Hostel accommodation is normally available for single men.

5 day week; good welfare, canteen and recreational facilities; superannuation and life assurance scheme.

Good salaries based on experience and qualifications.

Applications will be treated as confidential and should be made, giving details of age, qualifications, experience and salary required to :-

Manager/Personnel **STEWARTS AND LLOYDS LIMITED**
CORBY, NORTHANTS.

E83 A

THE ROVER CO., LTD., SOLIHULL

EXPERIENCED SENIOR CAR DEVELOPMENT ENGINEERS

are required for interesting new car projects in an expanding engineering programme.

SALARY

Dependent on qualifications and experience, the salary grade is up to £1500 per annum.

PENSIONS

A Staff Contributory Pension Scheme is available after a short period of service.

LOCATION

The company's Head Office and Assembly Plant is situated on the southern outskirts of Birmingham and is adjacent to many attractive residential districts.

Applications, with full particulars, should be addressed to : Labour Manager, The Rover Co. Ltd., Lode Lane, Solihull, Warwicks. E7717 A

Classified Advts. continued on page 8

SITUATIONS VACANT

DESIGNER DRAUGHTSMEN

Men with flair for design work required by well-established and progressive Engineering firm in South West London. This Company is engaged in building Paper Making Machinery which presents interesting engineering problems. There are opportunities for studying equipment in the field, and working on new projects.

Applicants should have qualifications at least equal to Higher National Certificate. There is a pension scheme, and the prospects and salary are very good. Reply.—BOX No. E7930, "The Engineer." A

CHIEF DEVELOPMENT ENGINEER

A vacancy exists in a modern and expanding company of Scientific and Electronic Instrument Makers in West London for an Engineer possessing good academic qualifications and extensive experience in the design and development of light Electro-Mechanical Precision Instruments. The position is an important and expanding one, carrying with it the responsibility, control and administration of existing design and development facilities, including Instrument and Electronic Laboratories, Design Drawing Office, Development Department, and Prototype Workshops, &c., &c.—Write, stating experience, age and full details.—BOX No. E7916, "The Engineer." A

GAS TURBINE COMBUSTION DEVELOPMENT

A senior appointment has now to be made in the ENGLISH ELECTRIC Gas Turbine Division at Whetstone, near Leicester.

An engineer with an Honours Degree and experience in development of combustion chambers and fuel systems in the gas turbine field is required to lead a young and energetic team.

Salary will be commensurate with the status of the successful applicant.

Applications, which will be treated in strict confidence, should be addressed to the Chief Engineer, Gas Turbine Dept., c/o Central Personnel Services, 336/7, Strand, W.C.2, quoting Ref. ER 1909C. E7918 A

SITUATIONS WANTED

BRITISHER, with 30 years' practical engineering experience and at present holding position of Chief Draughtsman with large American firm in one of their South American divisions, wishes to work with English company in position of responsibility calling for organisation and administrative capabilities.—BOX No. E1138, "The Engineer." B

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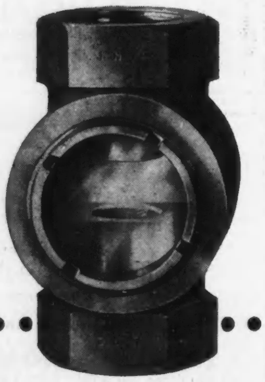

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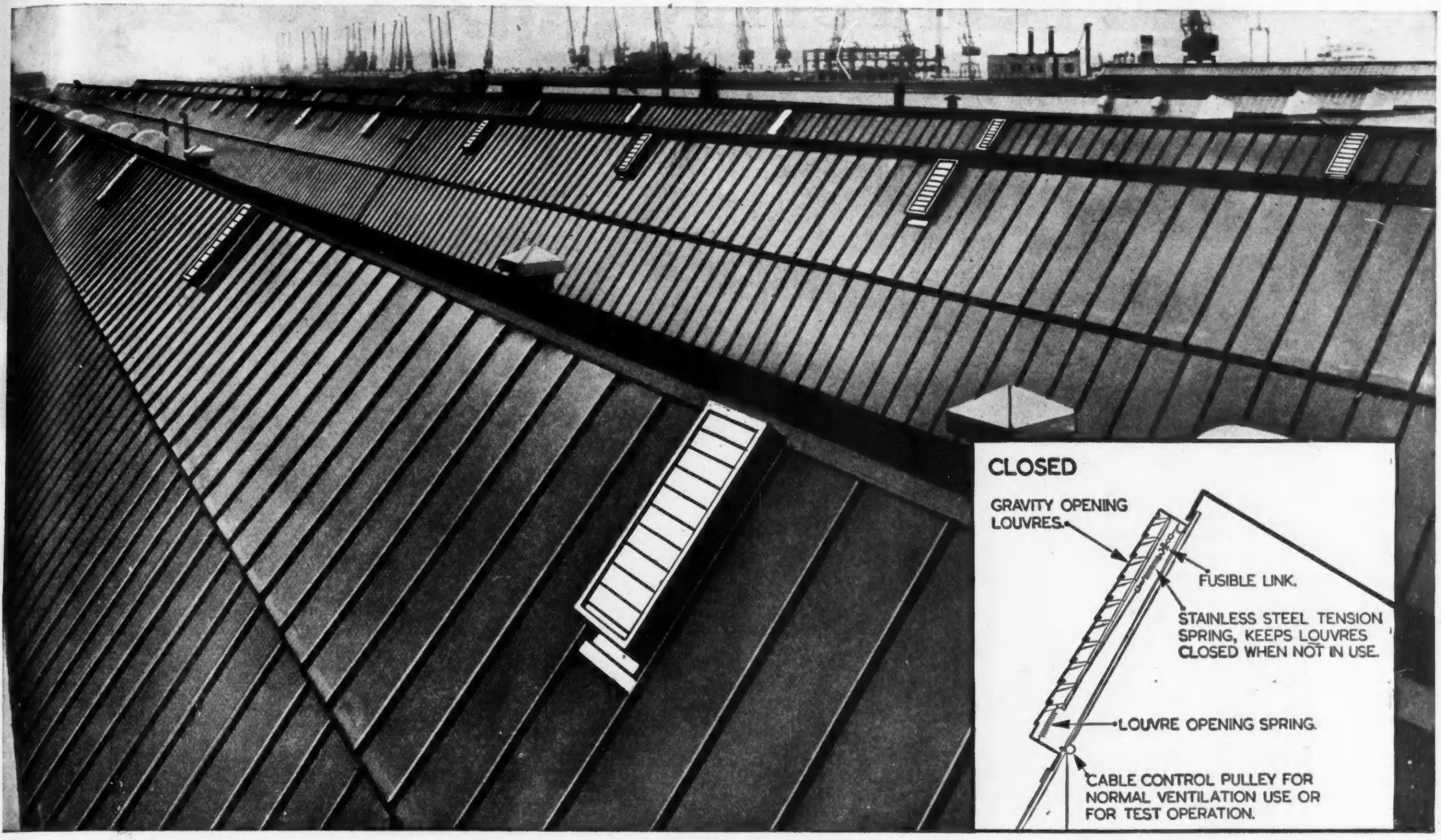
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at AC-Delco, Division of GENERAL MOTORS LTD., SOUTHAMPTON.

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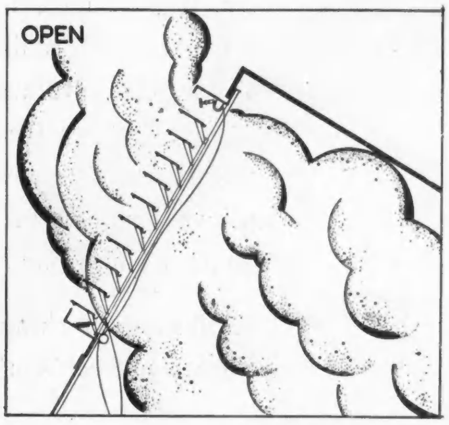

The insets illustrate the action of the ventilator as a Heat and Smoke Exhaust. In the event of fire, the fusible link fuses, providing Automatic Escape for Super-Heated Air and Smoke.

Write to Dept. S9/8B, for paper " Some Aspects of Fire Protection in Industrial Buildings" by M. J. Reaney, which deals fully with this matter.

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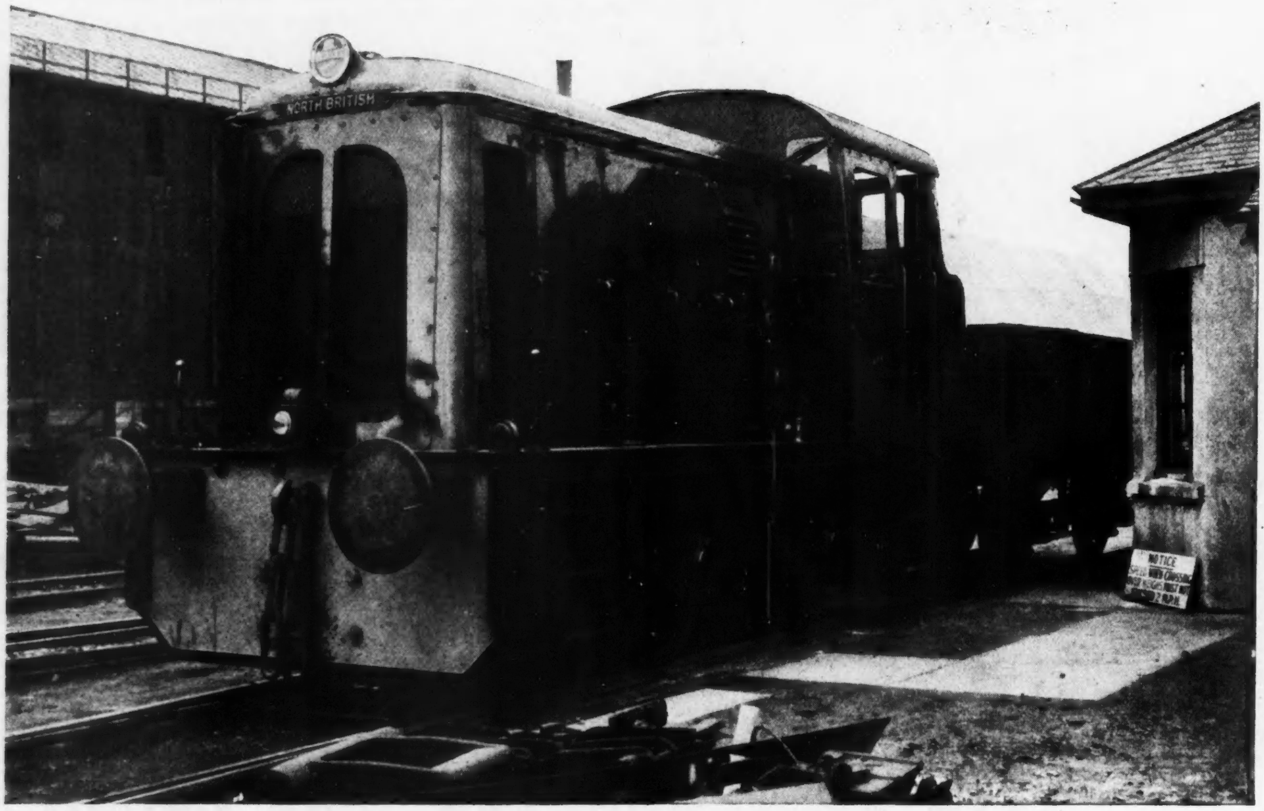

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The illustration shows a North British Diesel Hydraulic in use at Messrs. Colvilles, Clydebridge Steel Works. This 0–4–0 locomotive is inching a wagon over a weigh-bridge.

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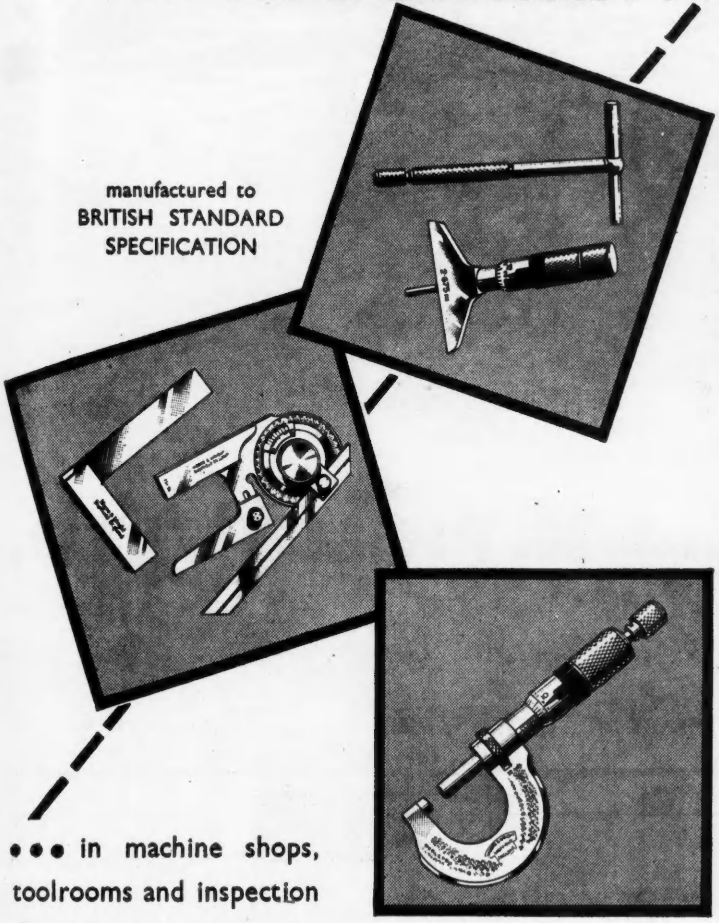

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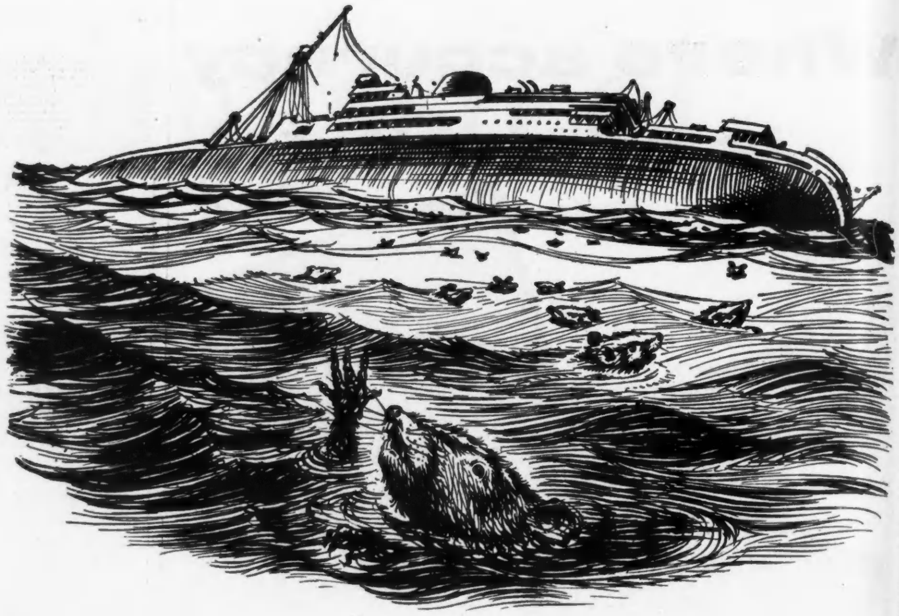

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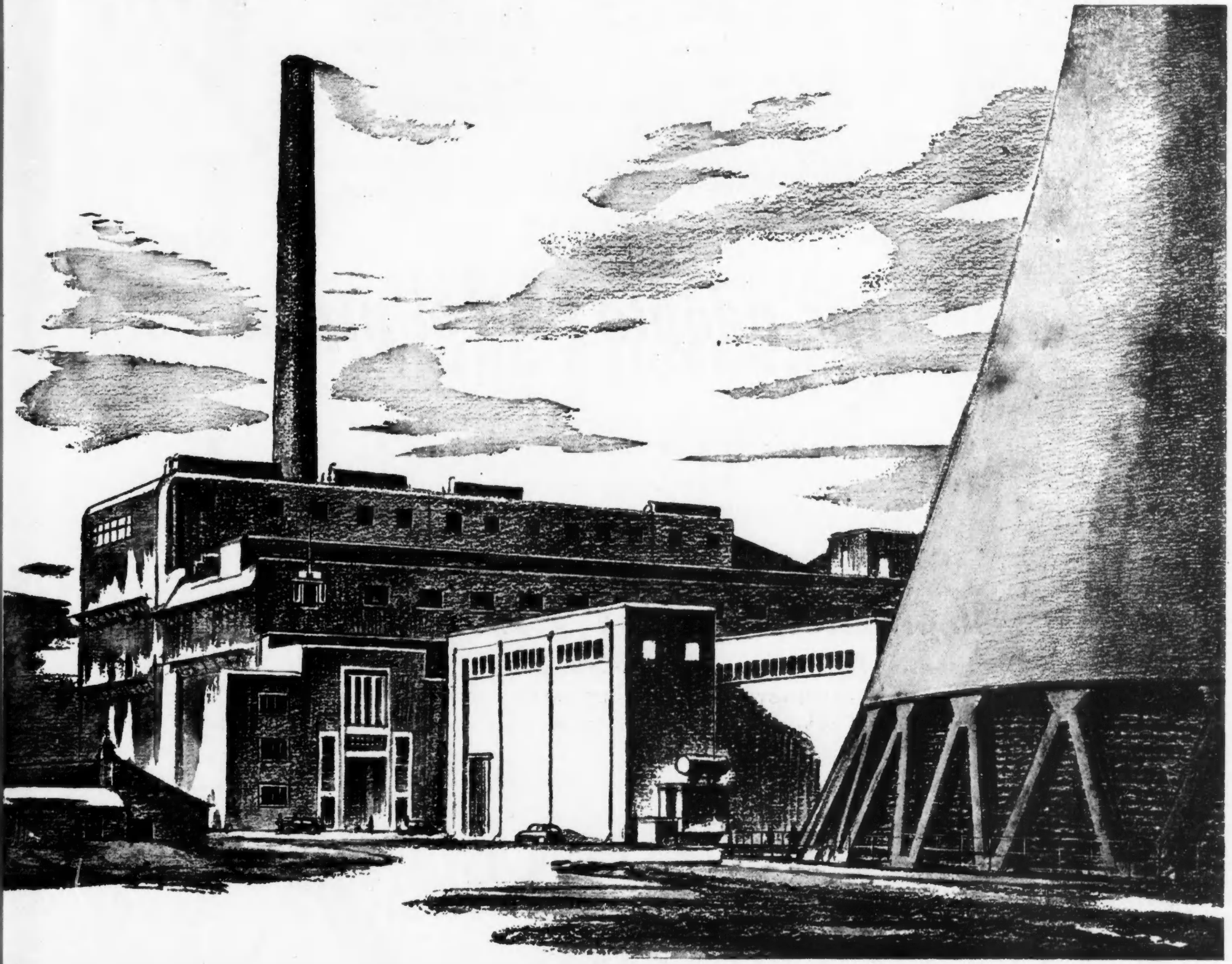

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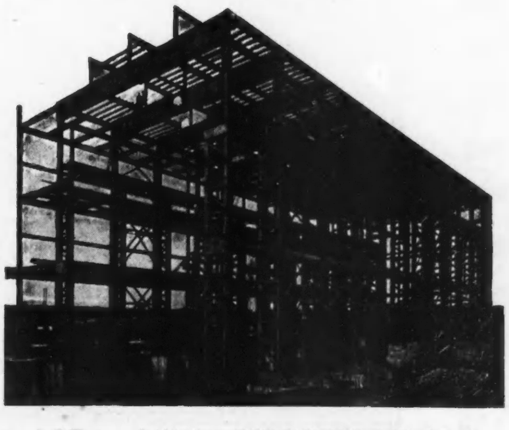

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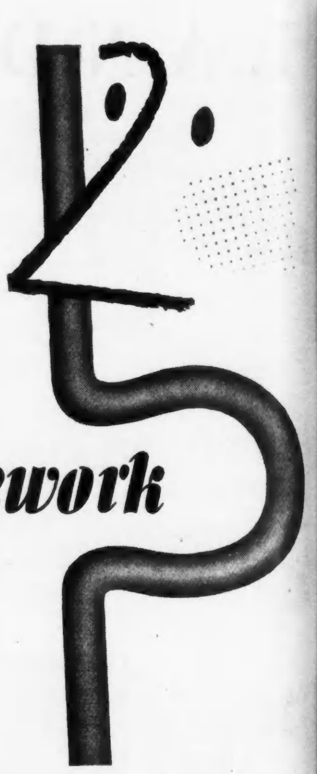

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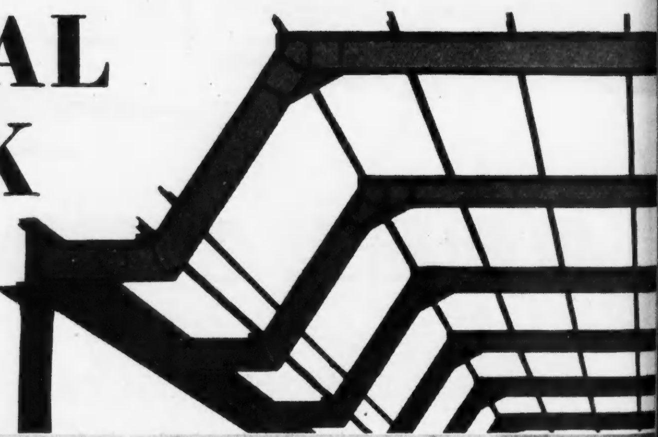

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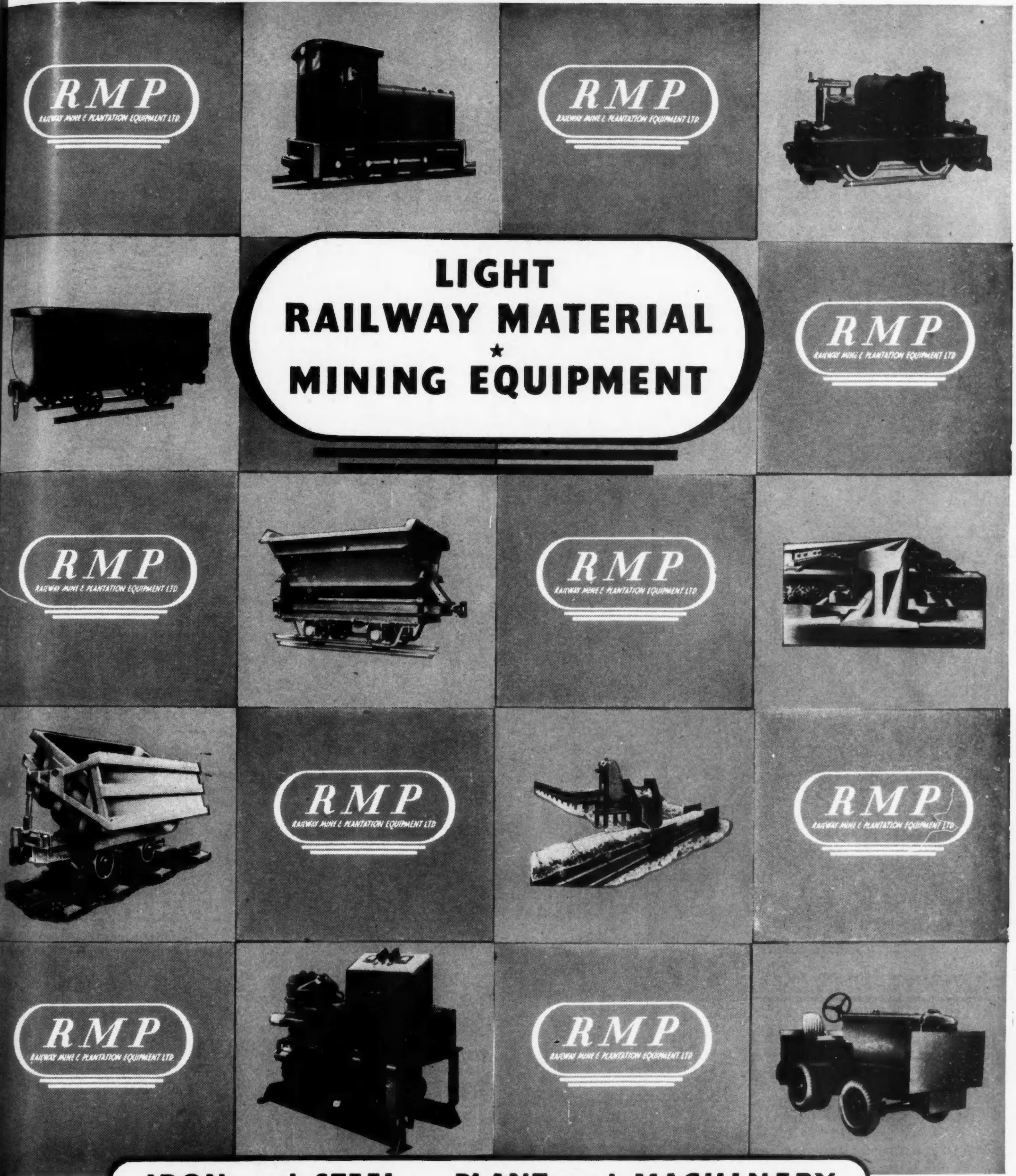
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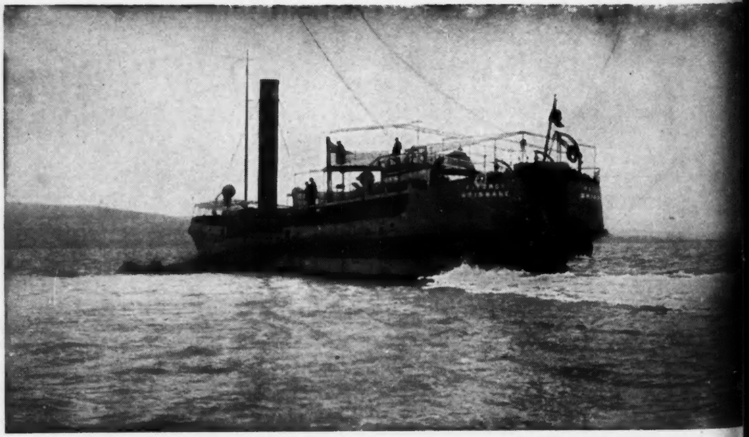

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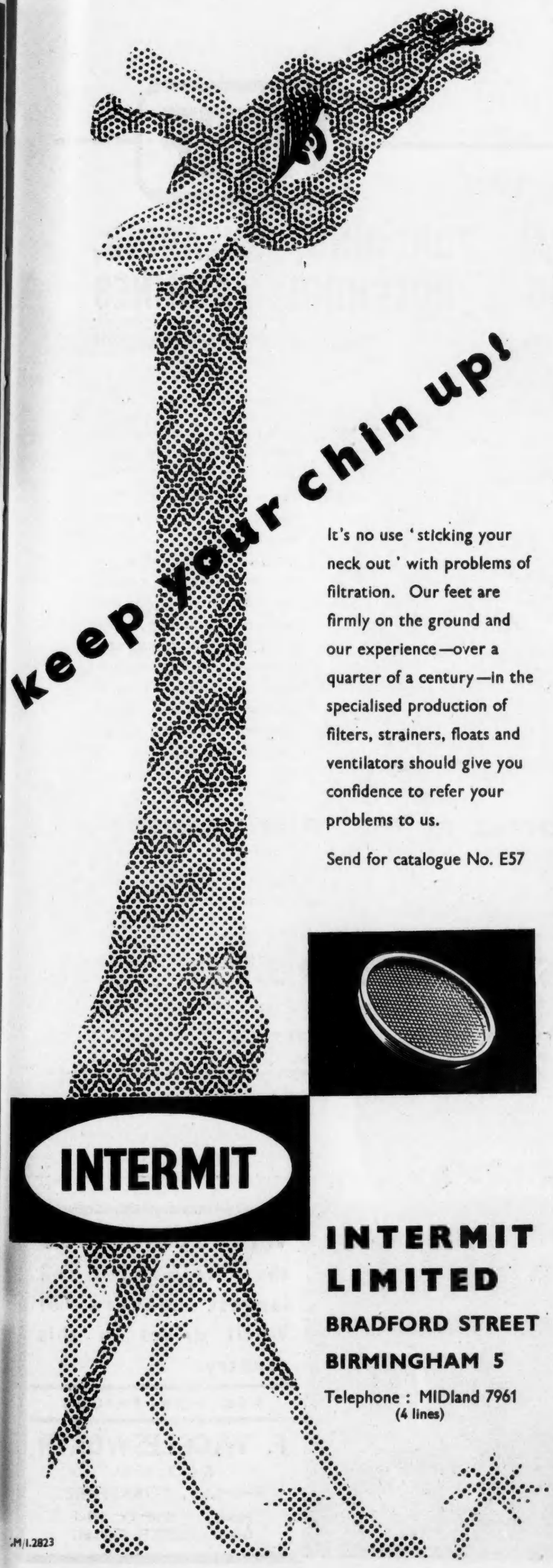

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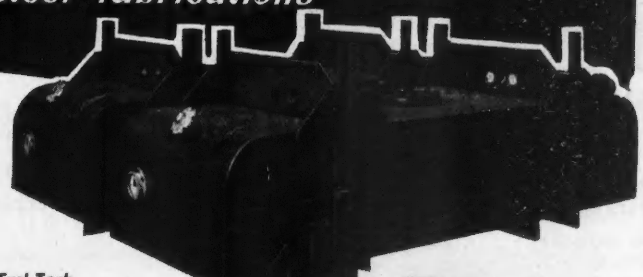

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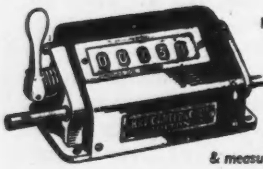

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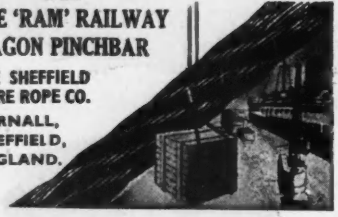

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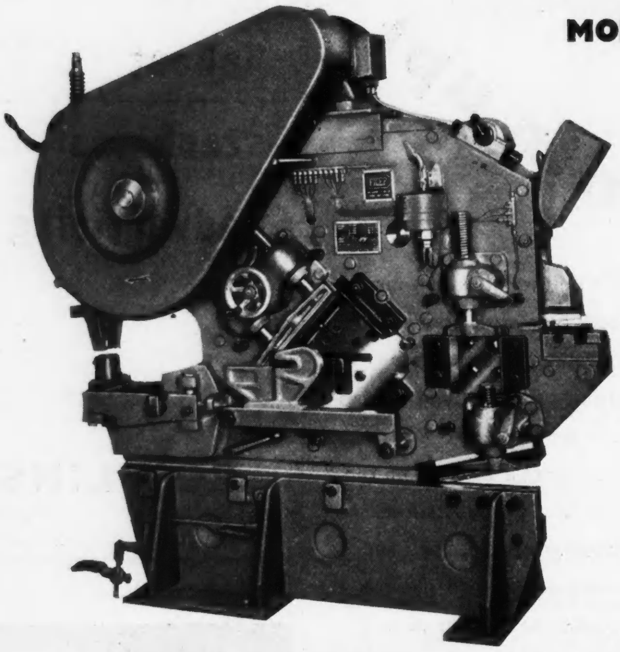

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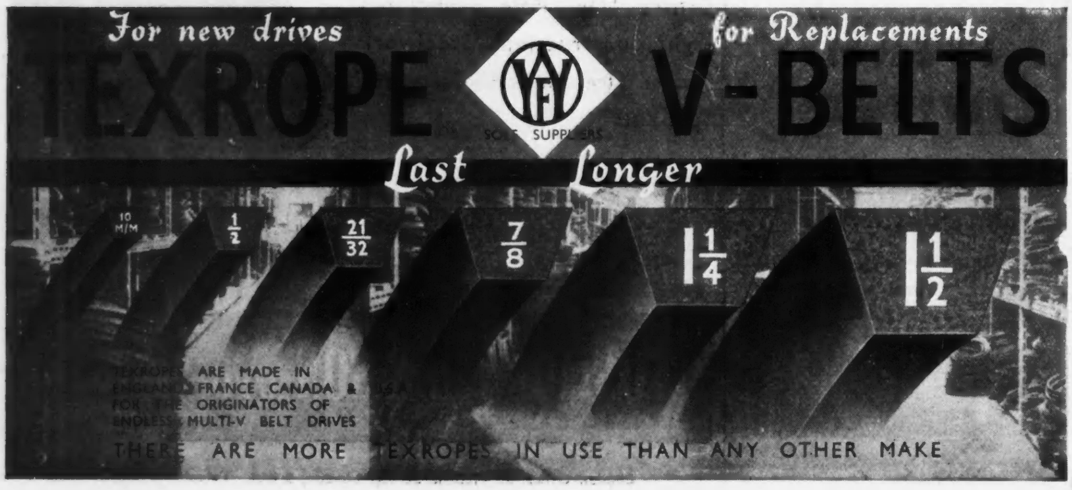

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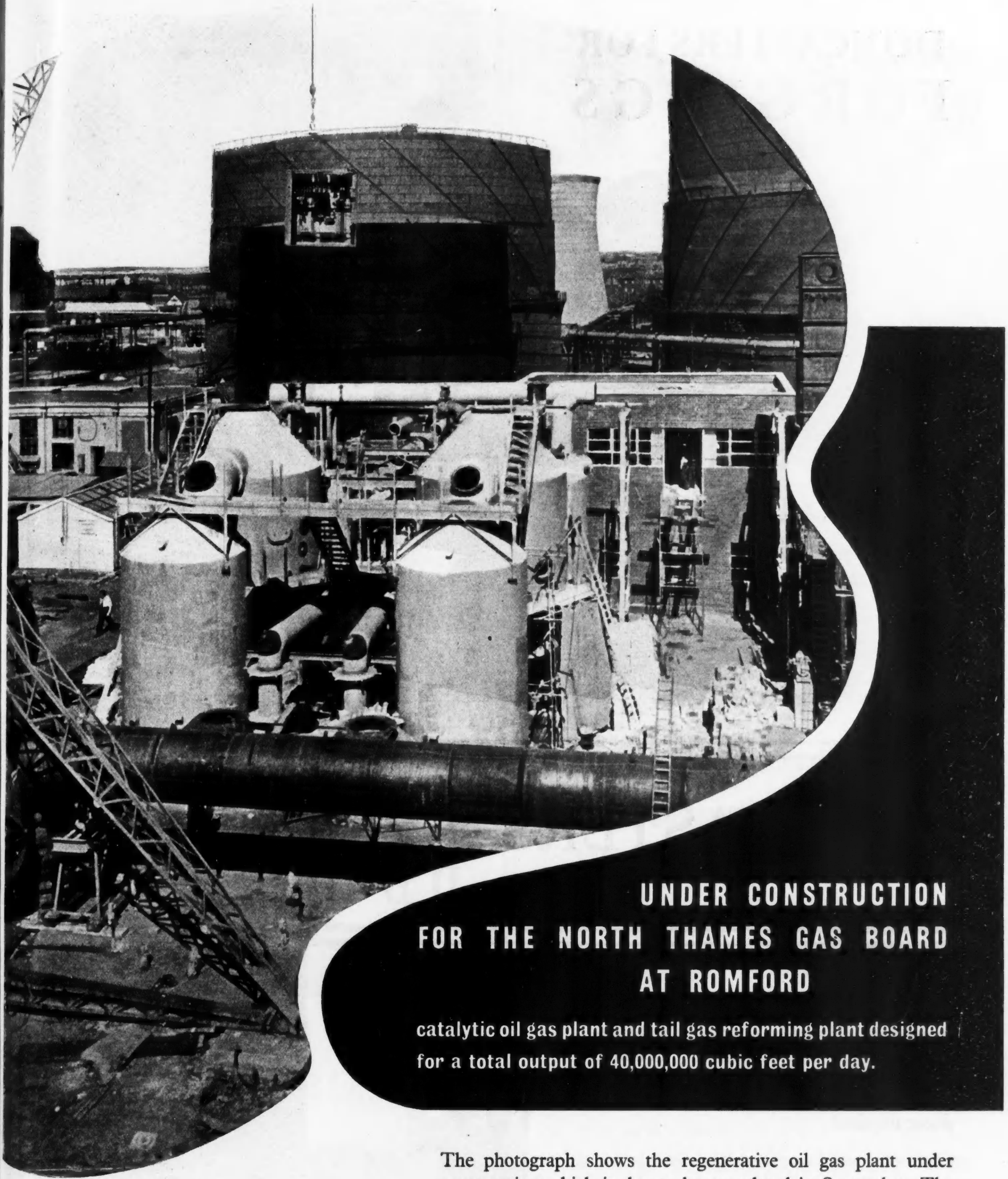

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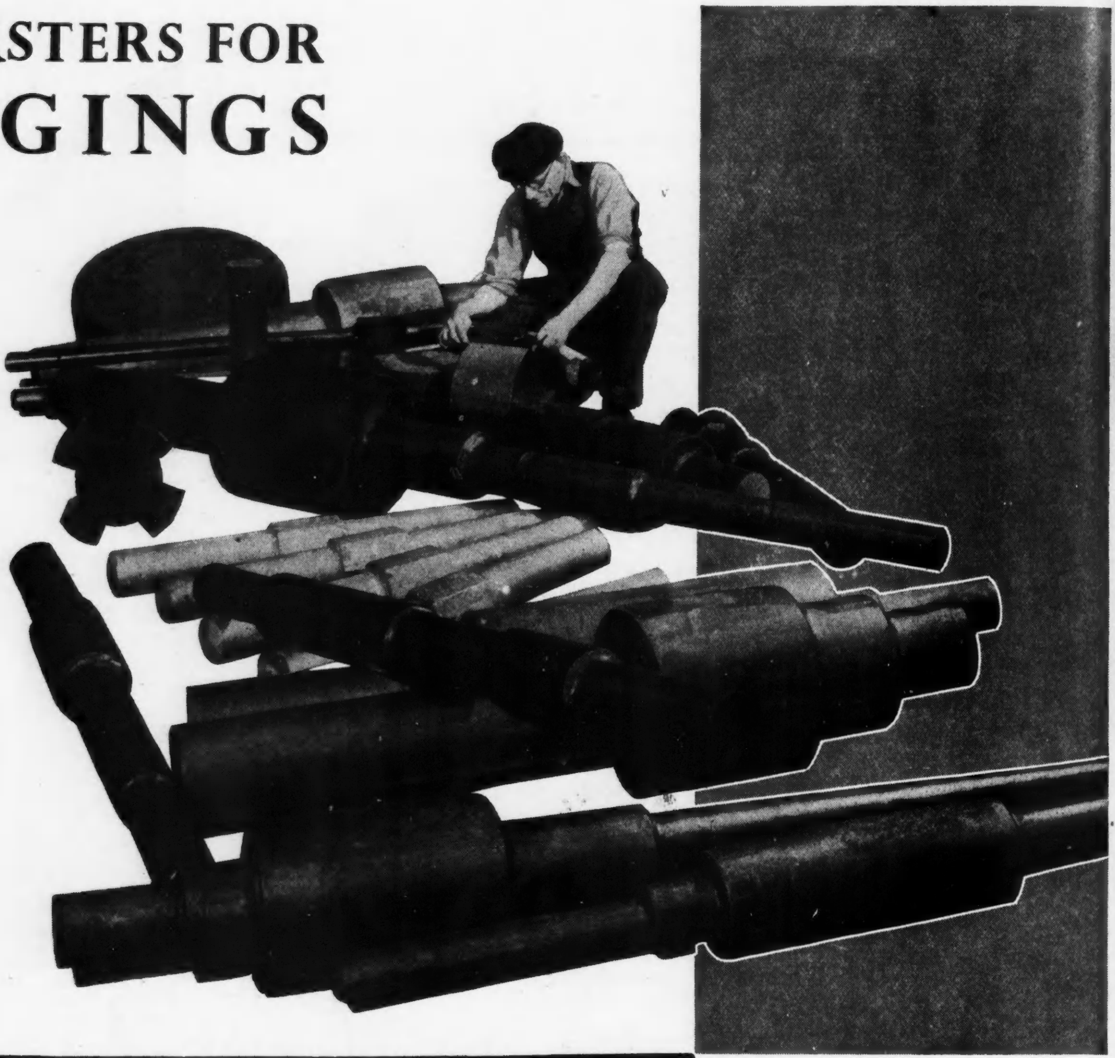

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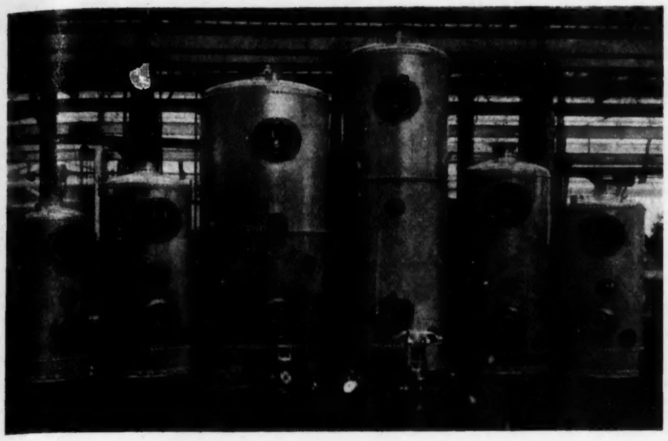

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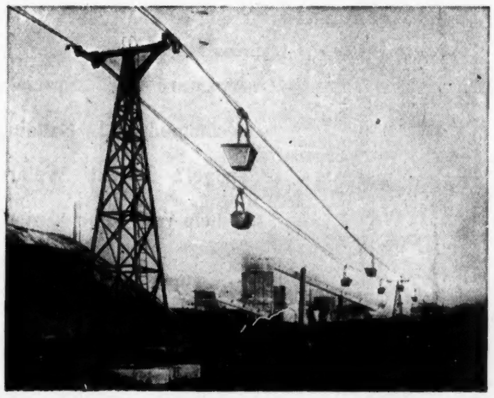

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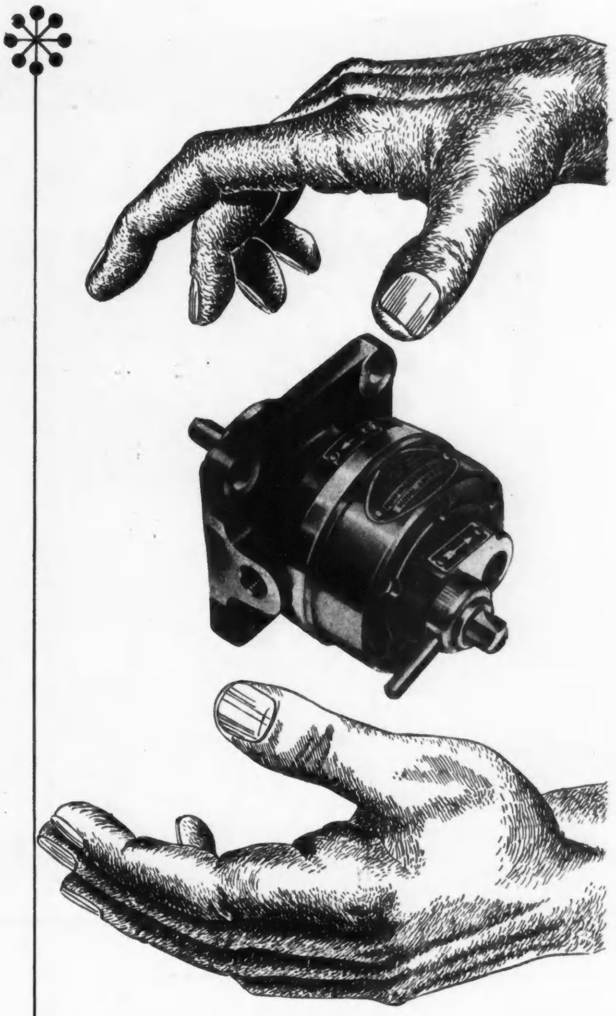

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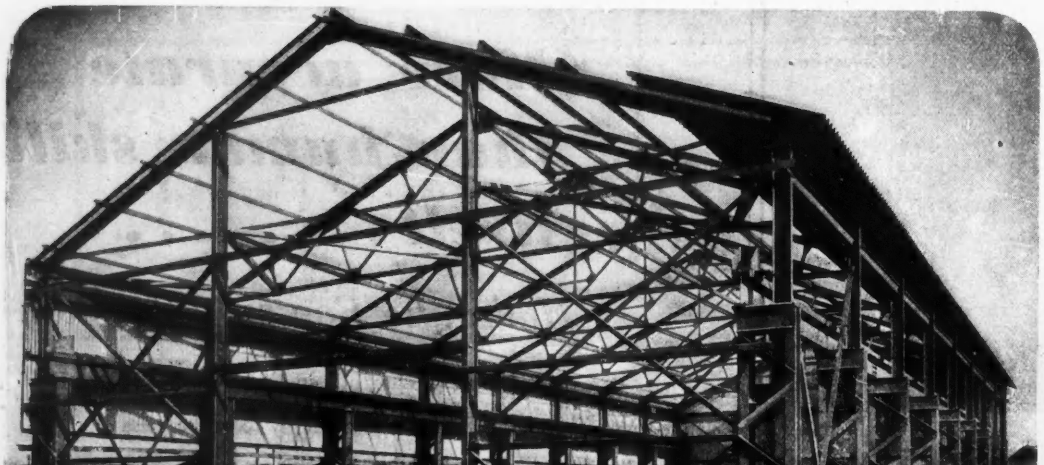

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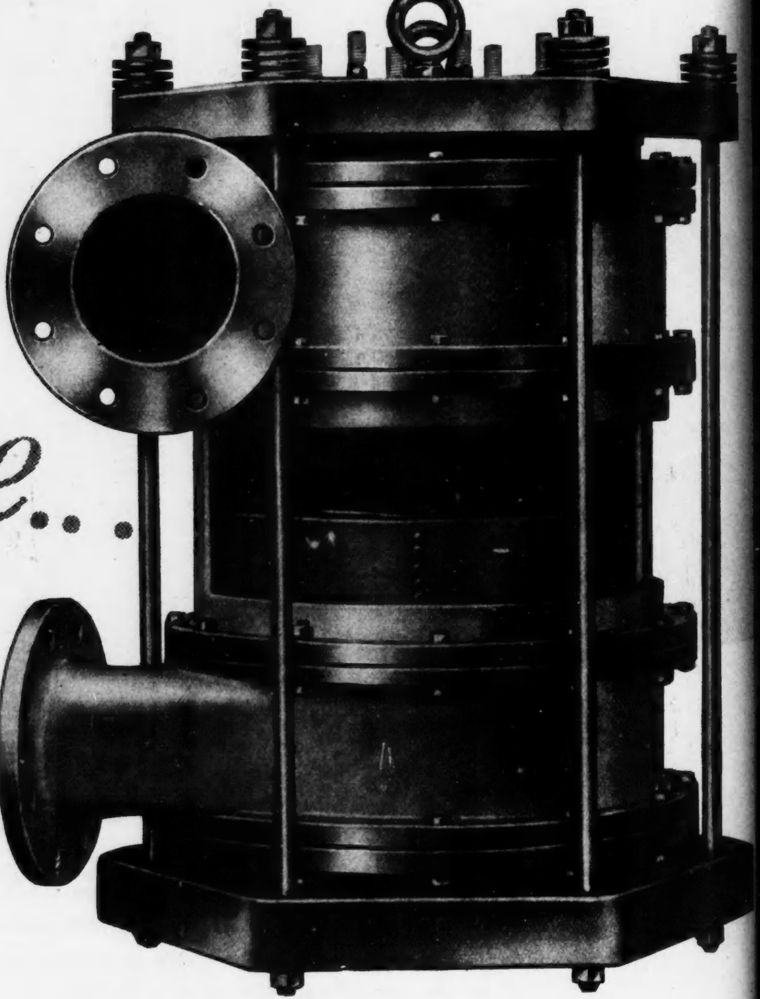

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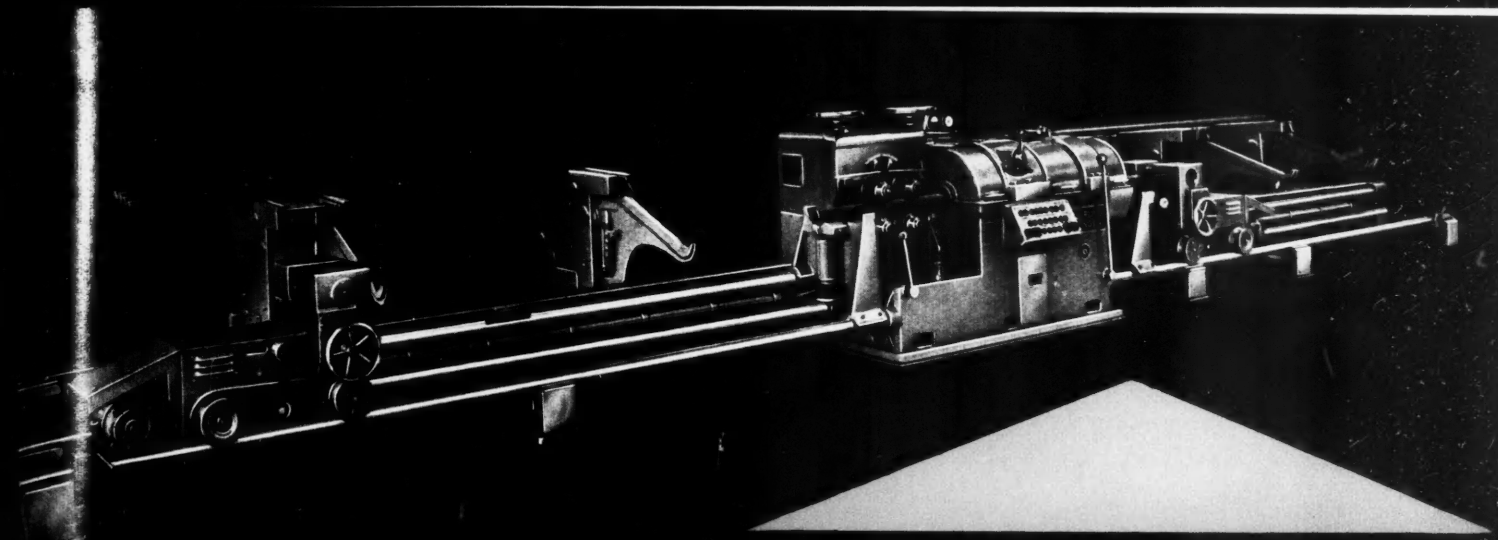

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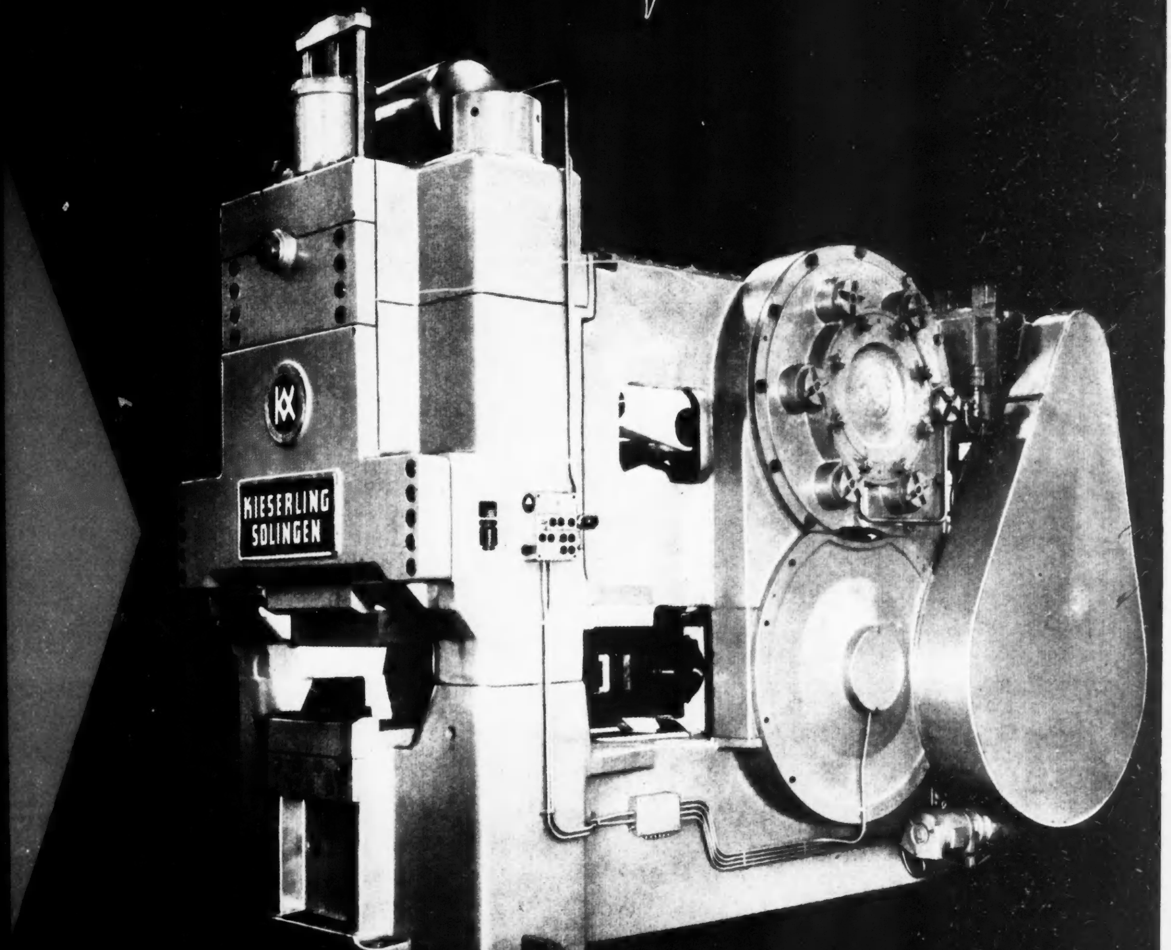

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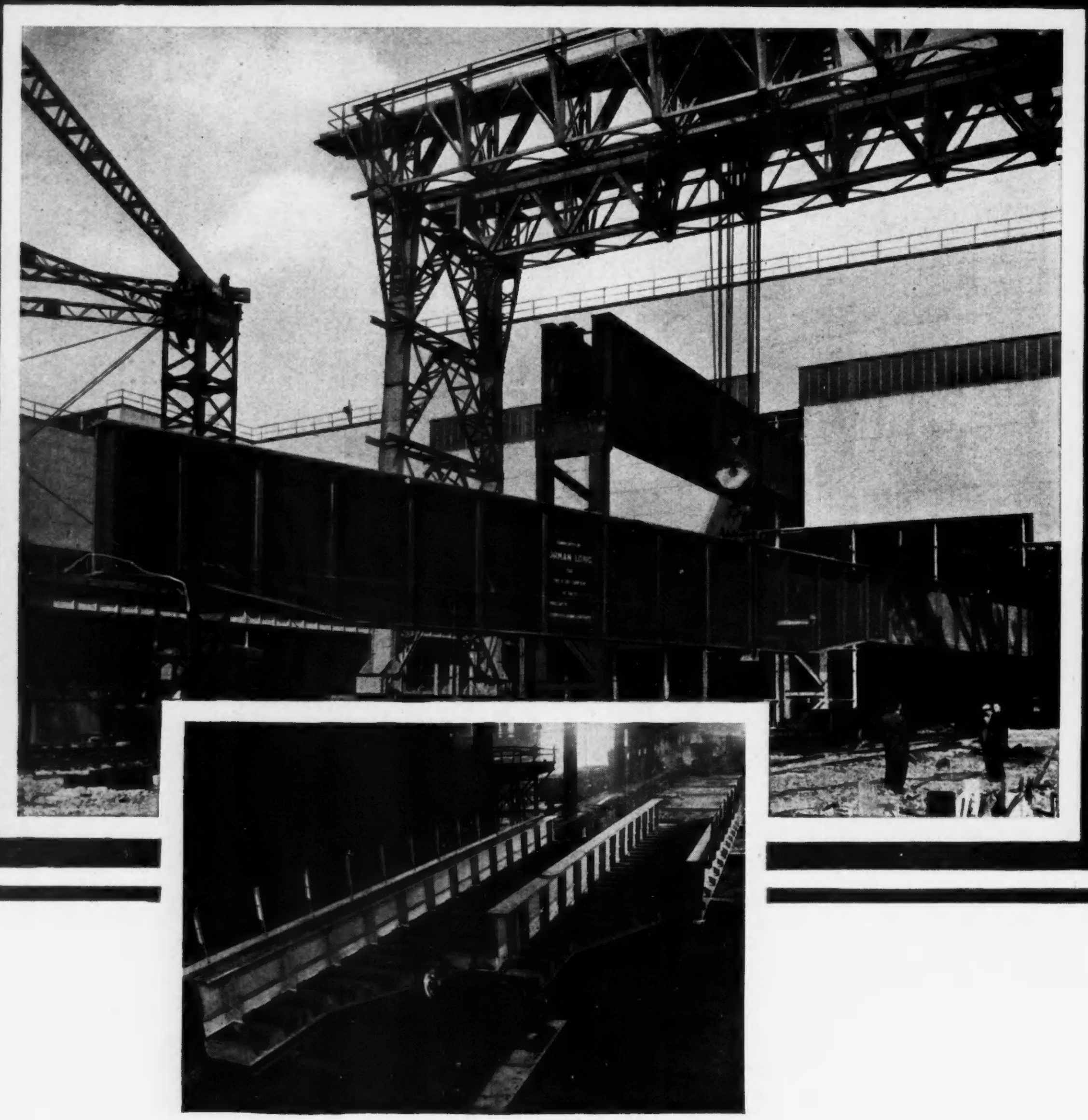

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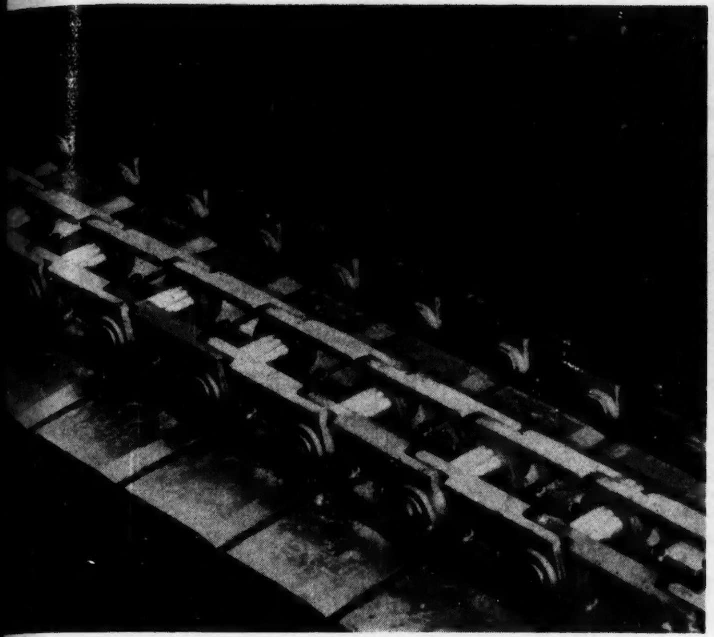

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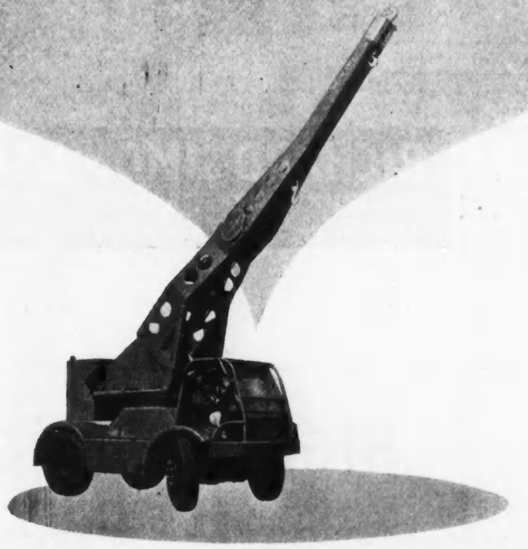

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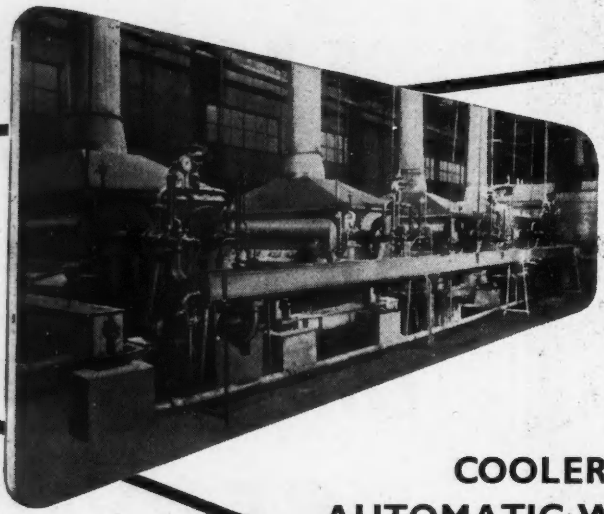

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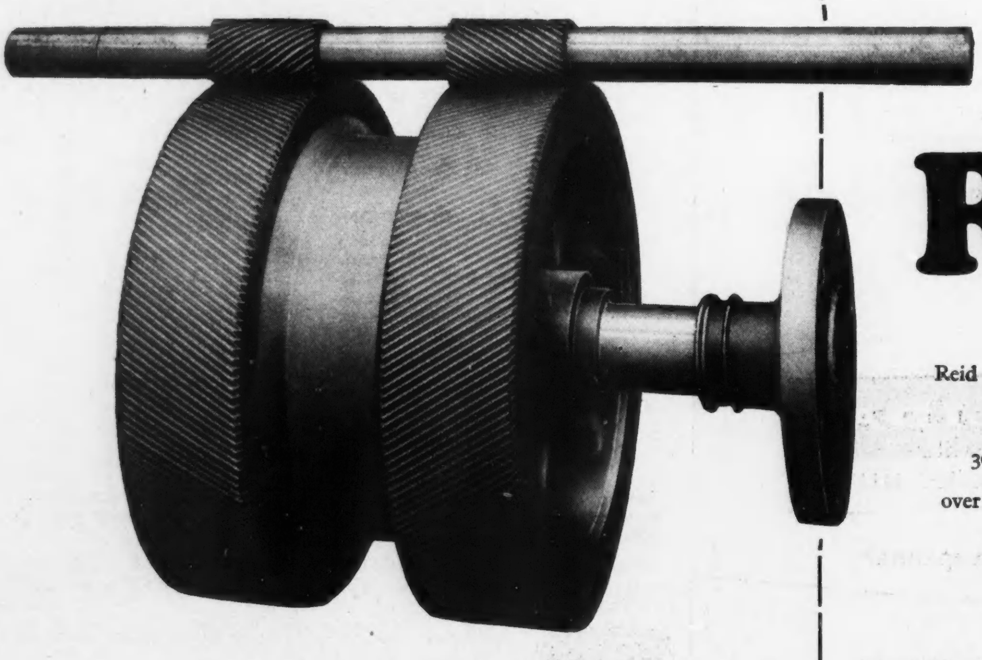

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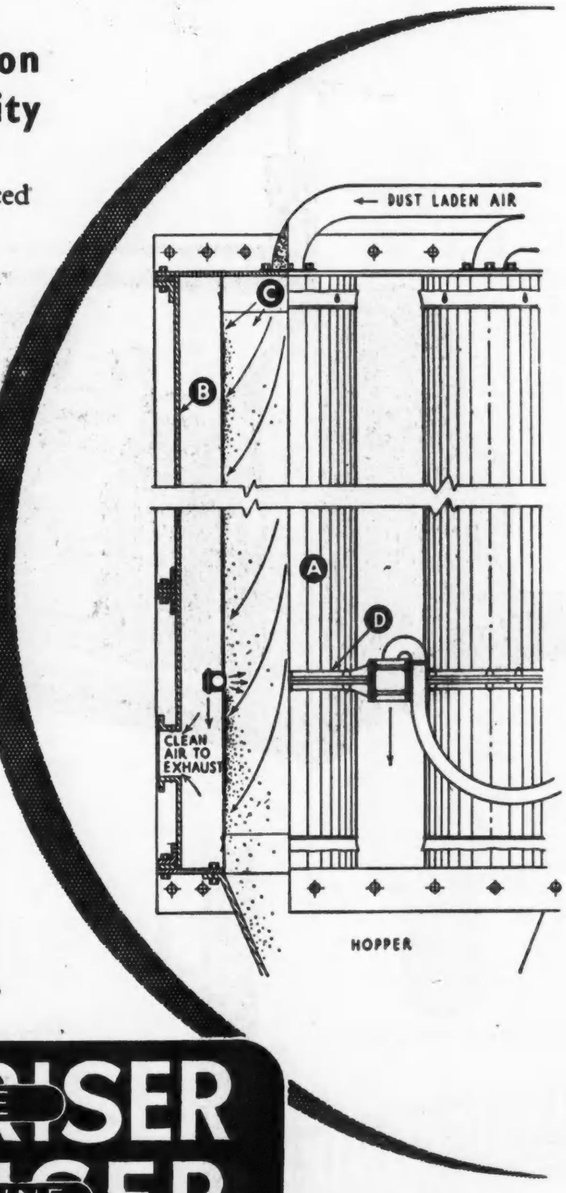

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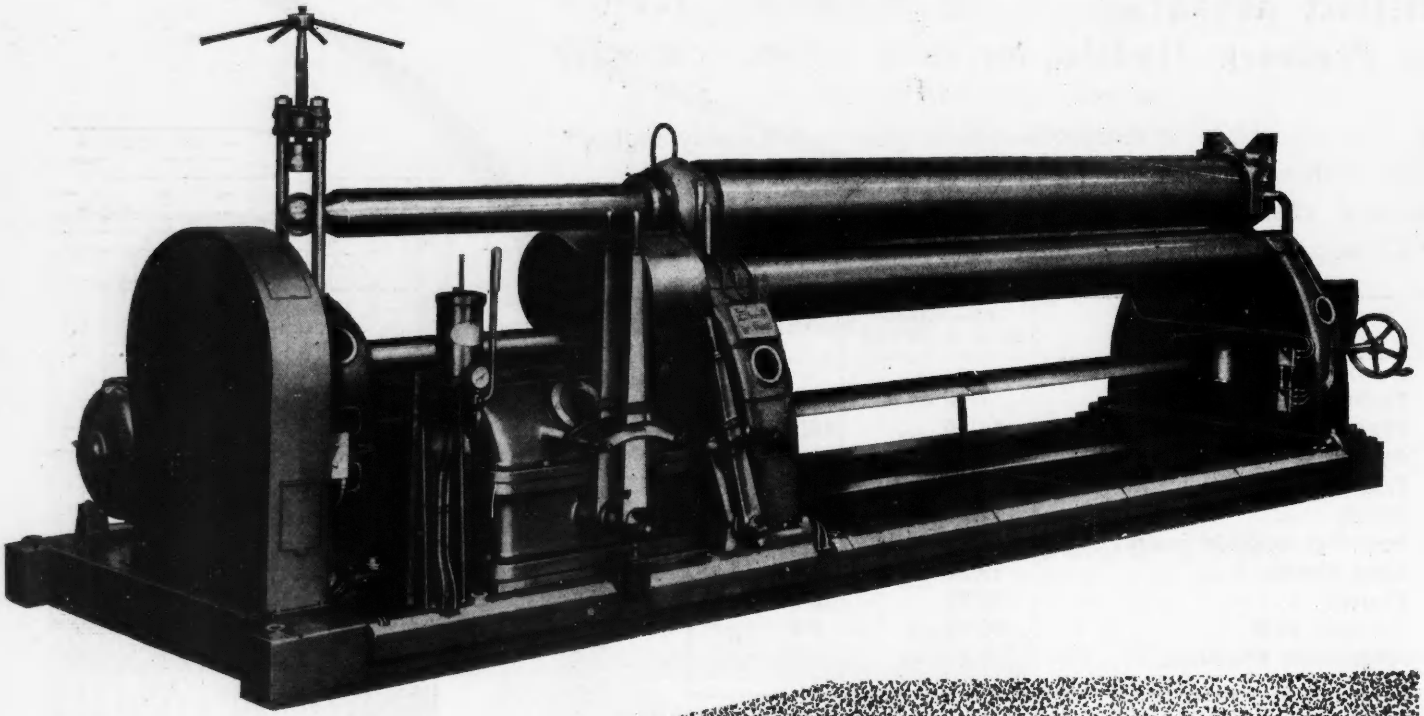

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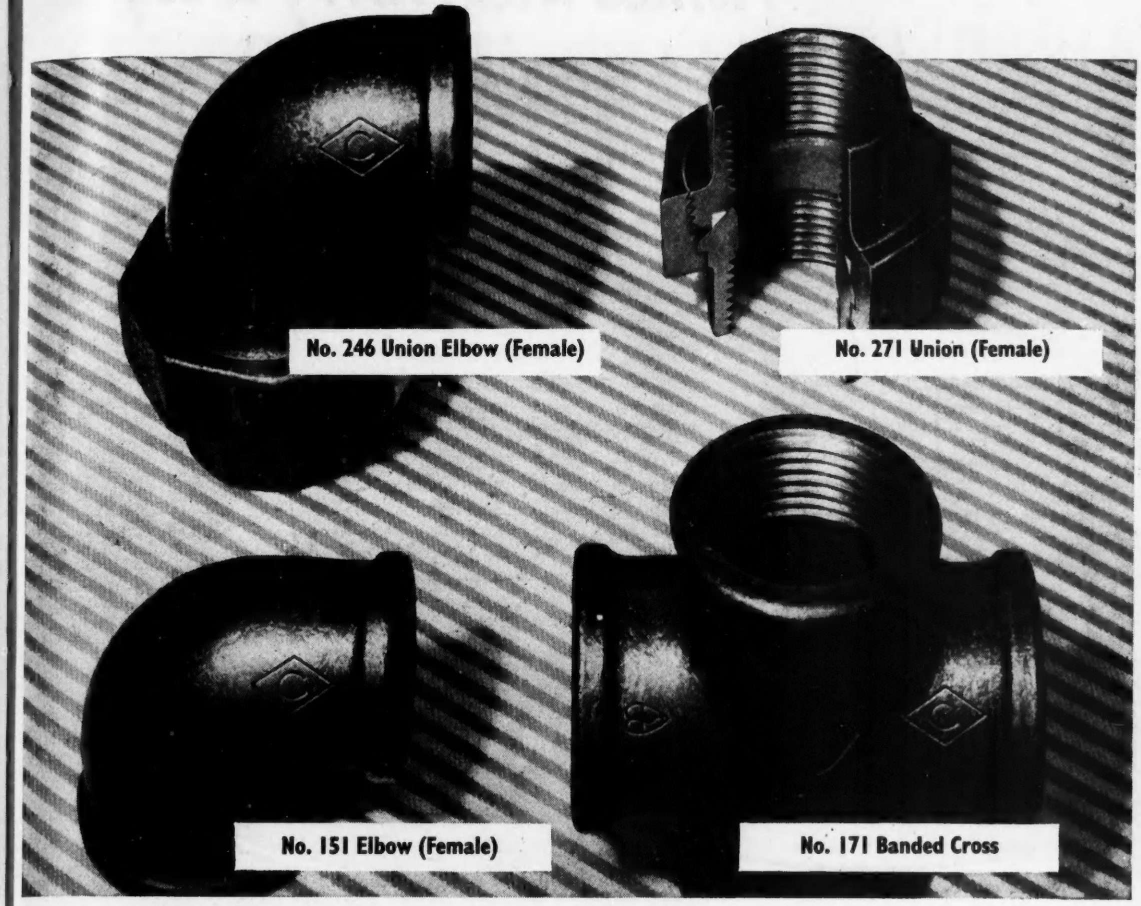

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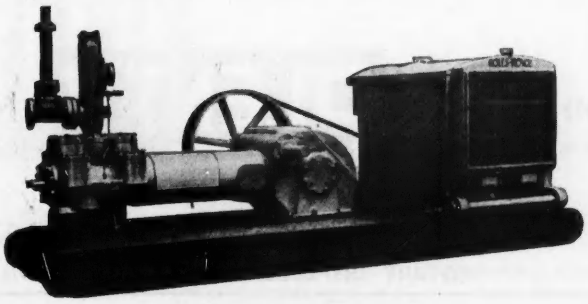

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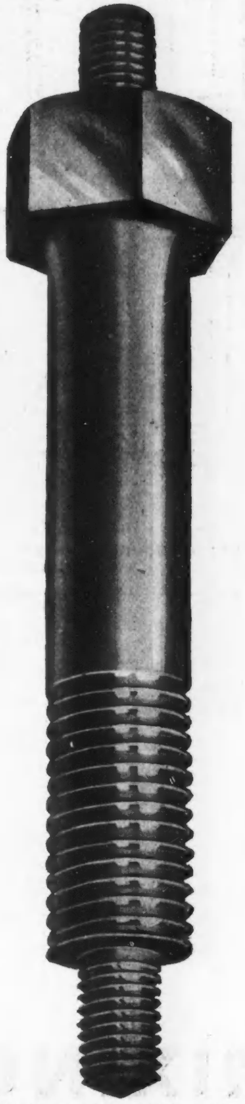

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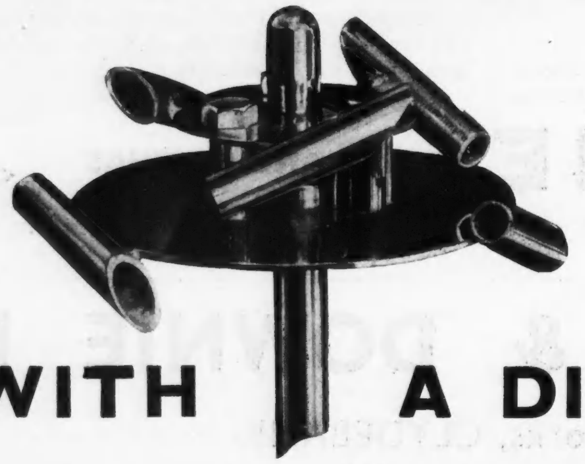

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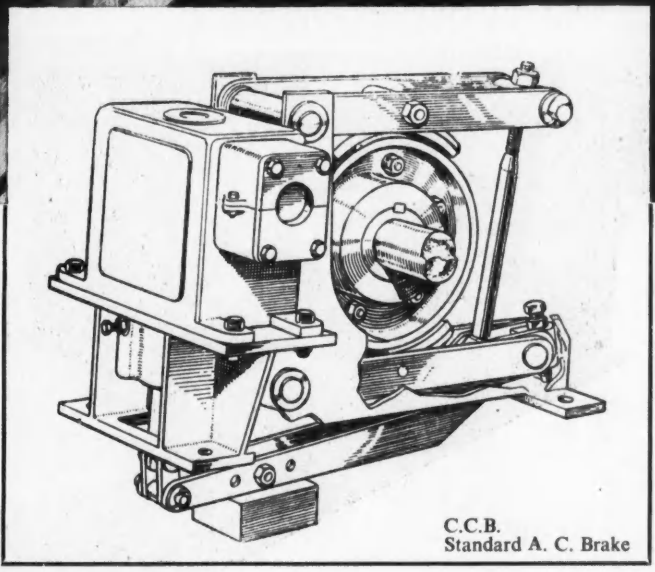

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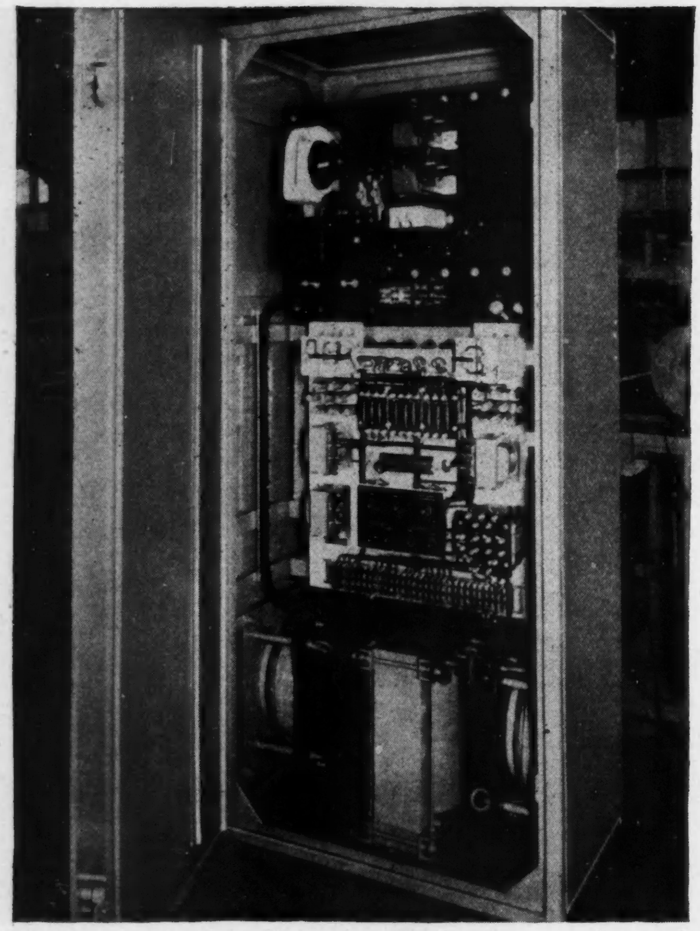

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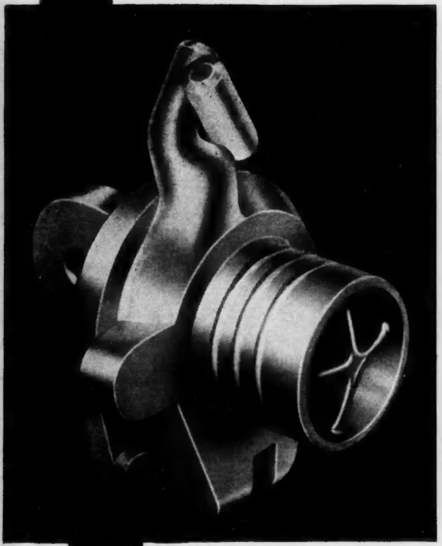

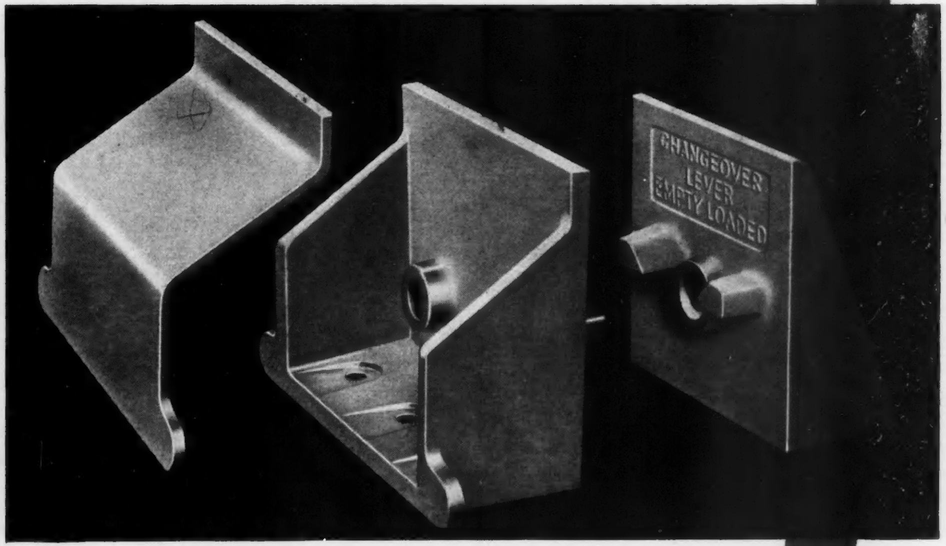

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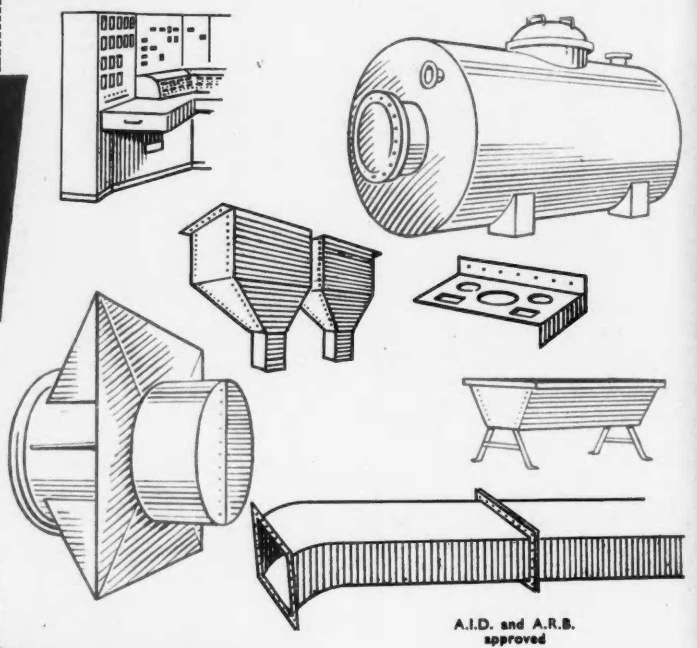

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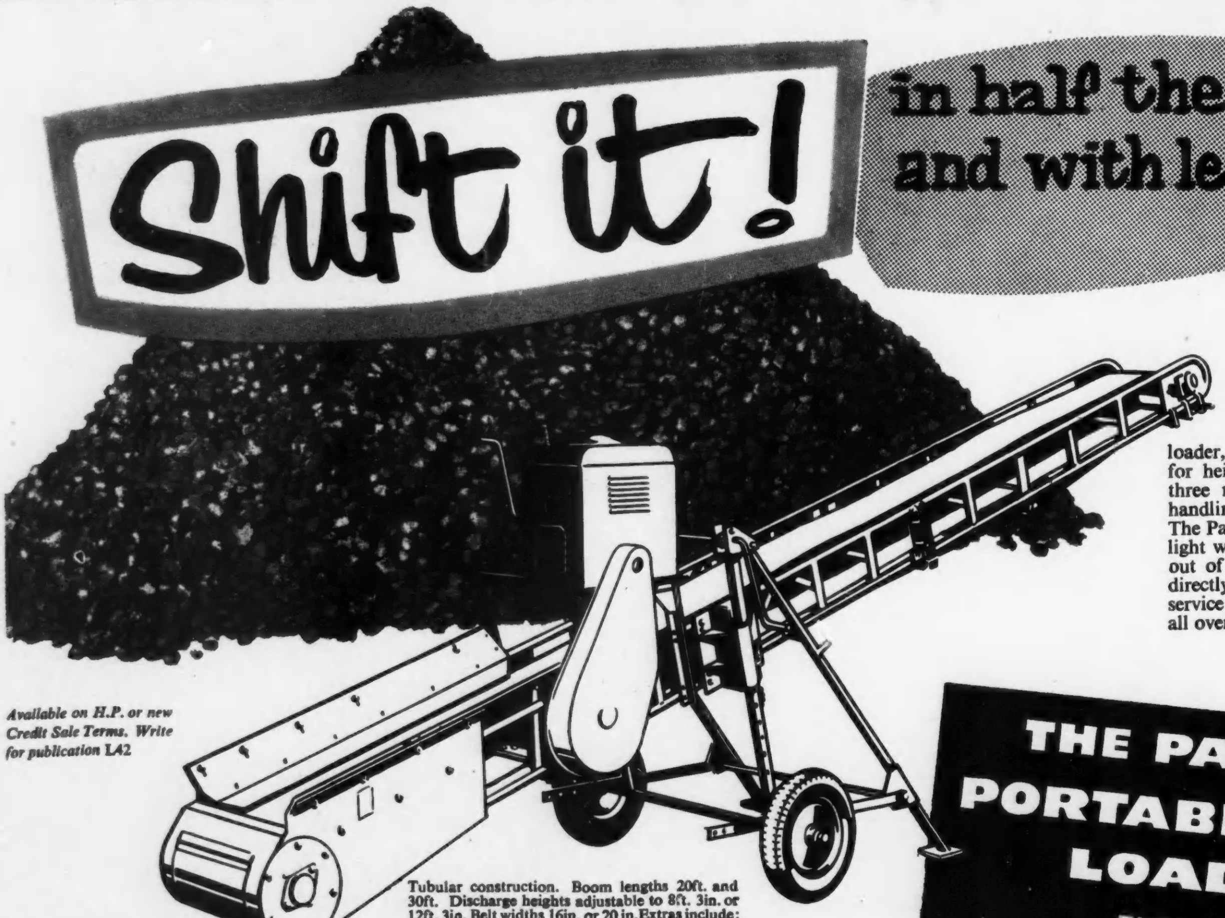

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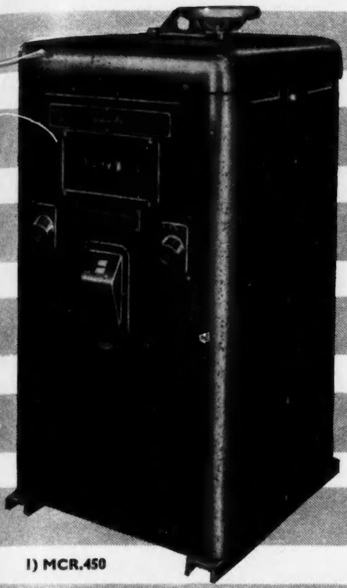
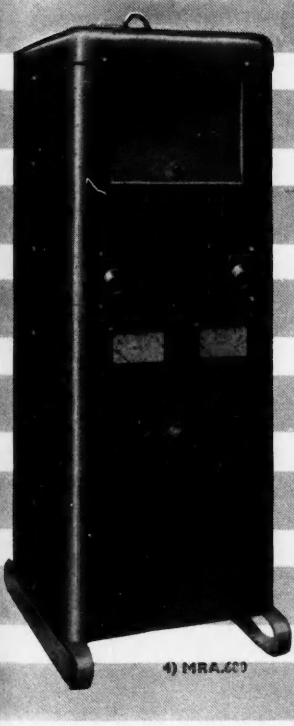

1) MCR.450

2) MR.375

3) MRS.425


4) MRA.600

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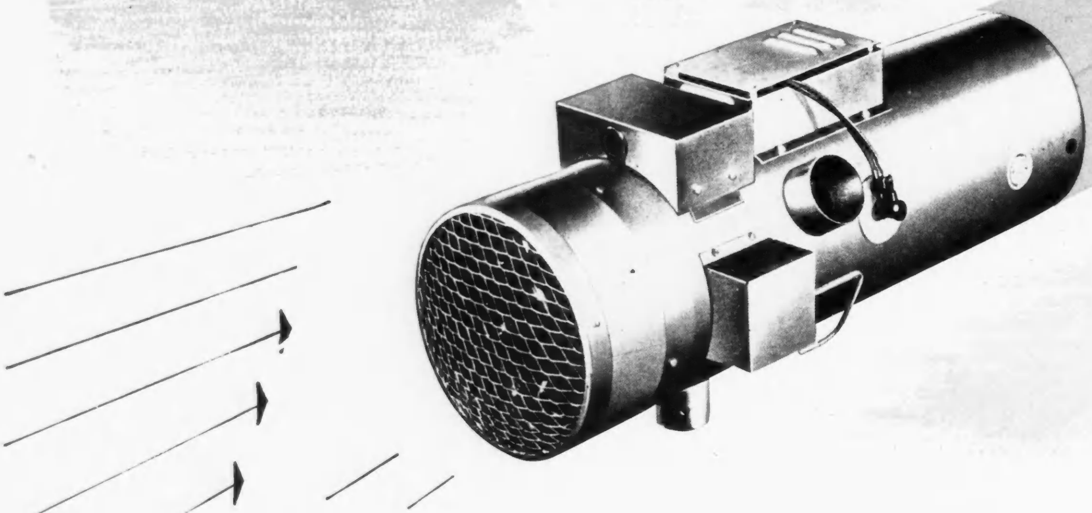

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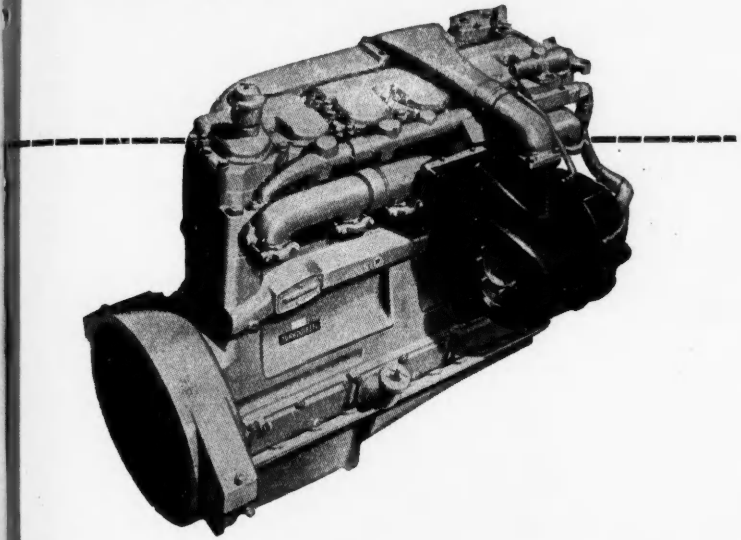

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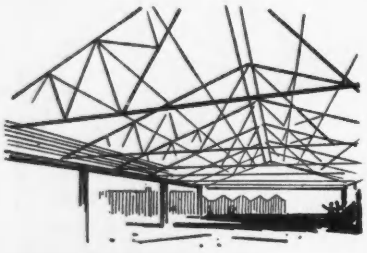

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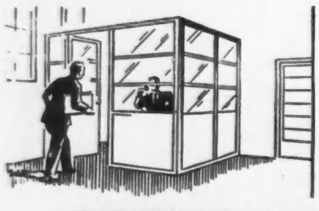

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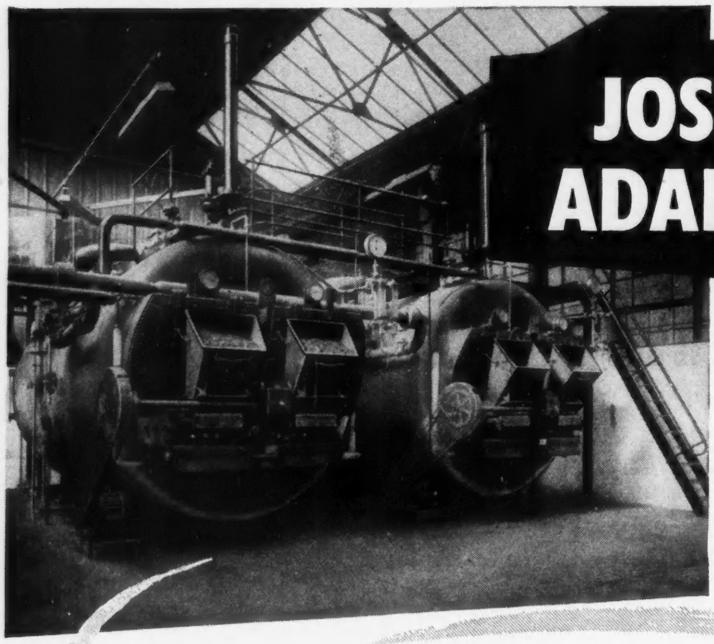

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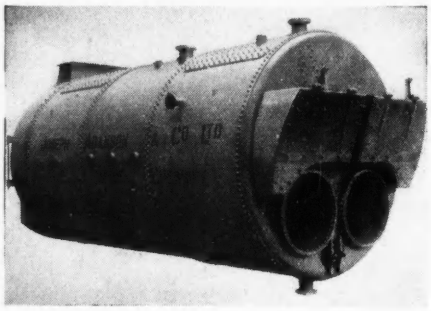

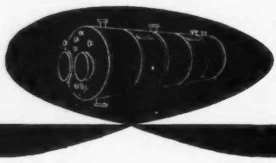

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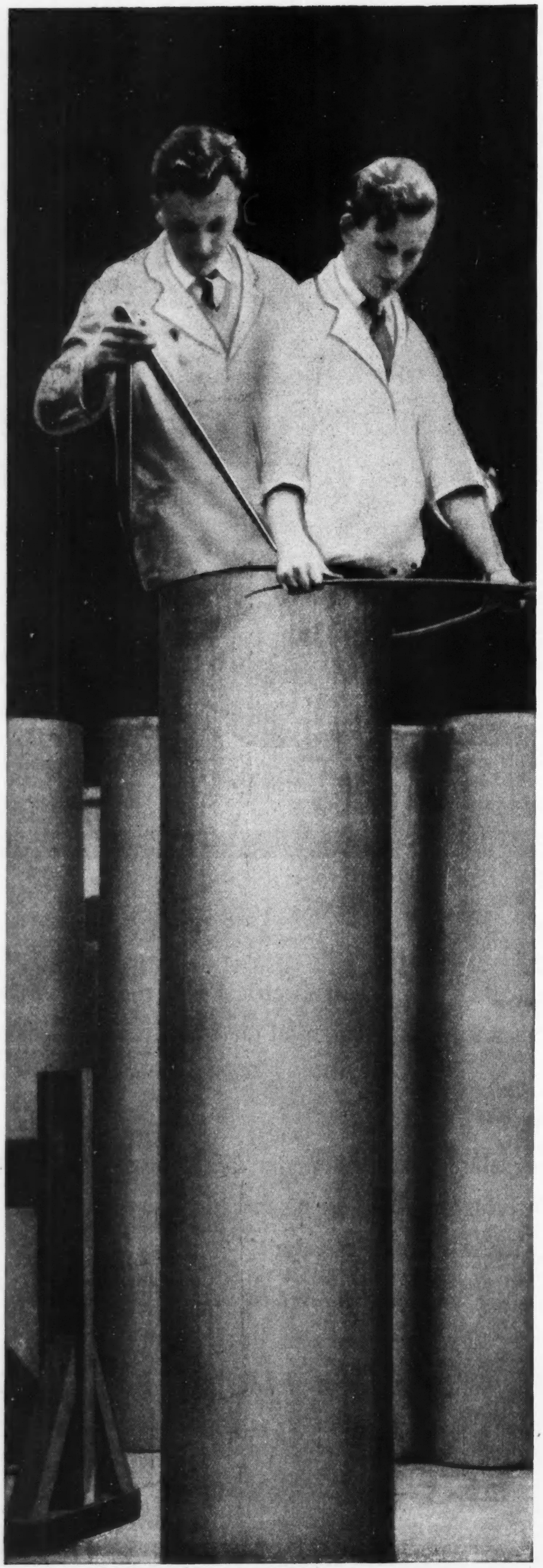

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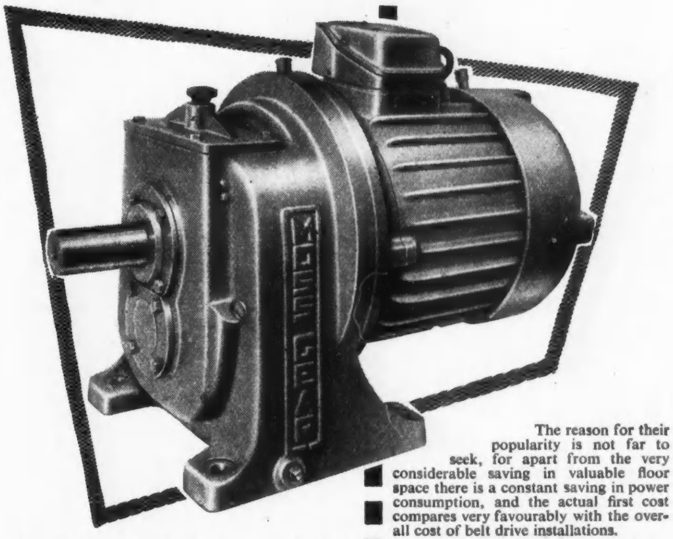

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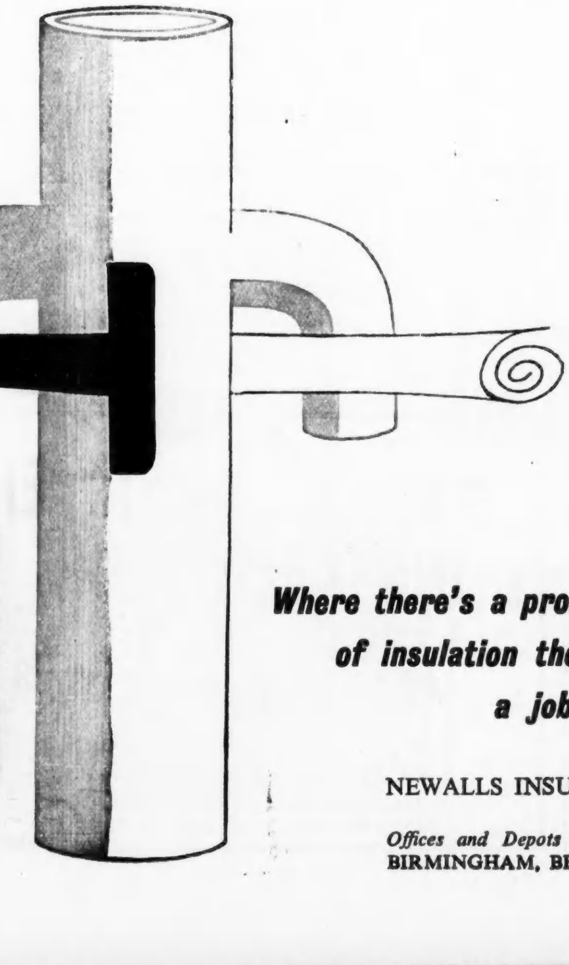

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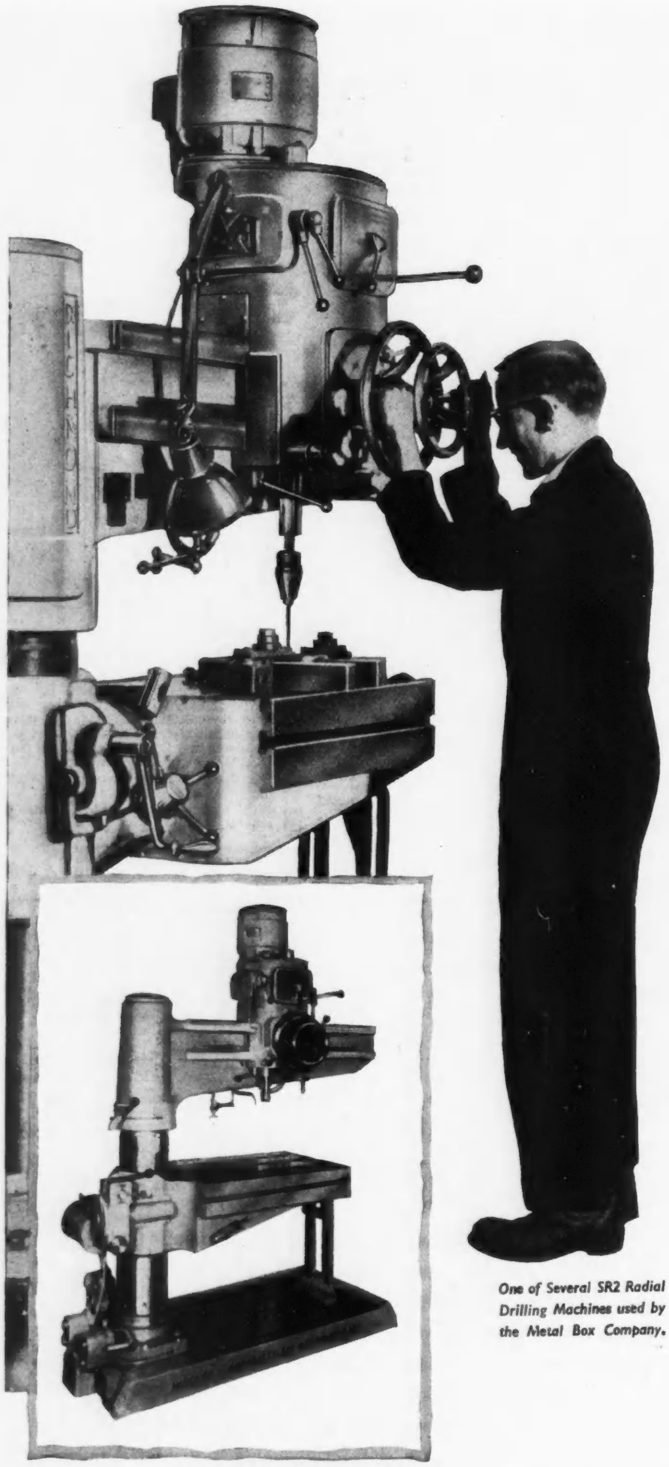

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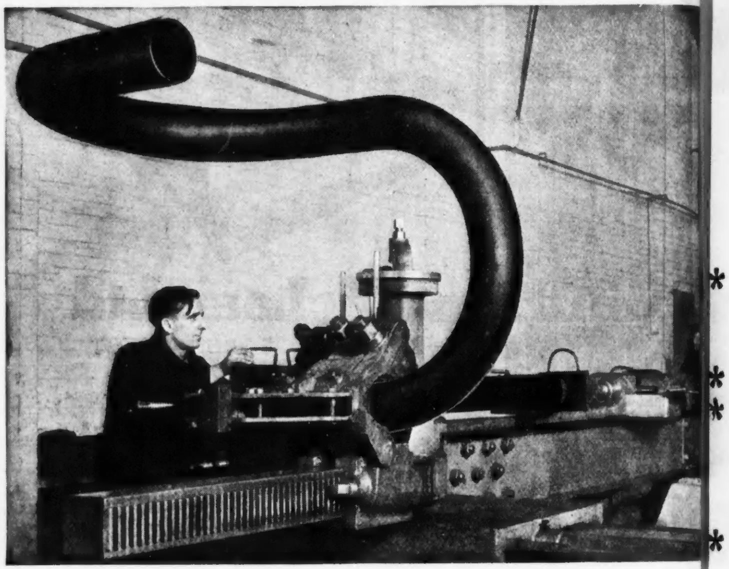

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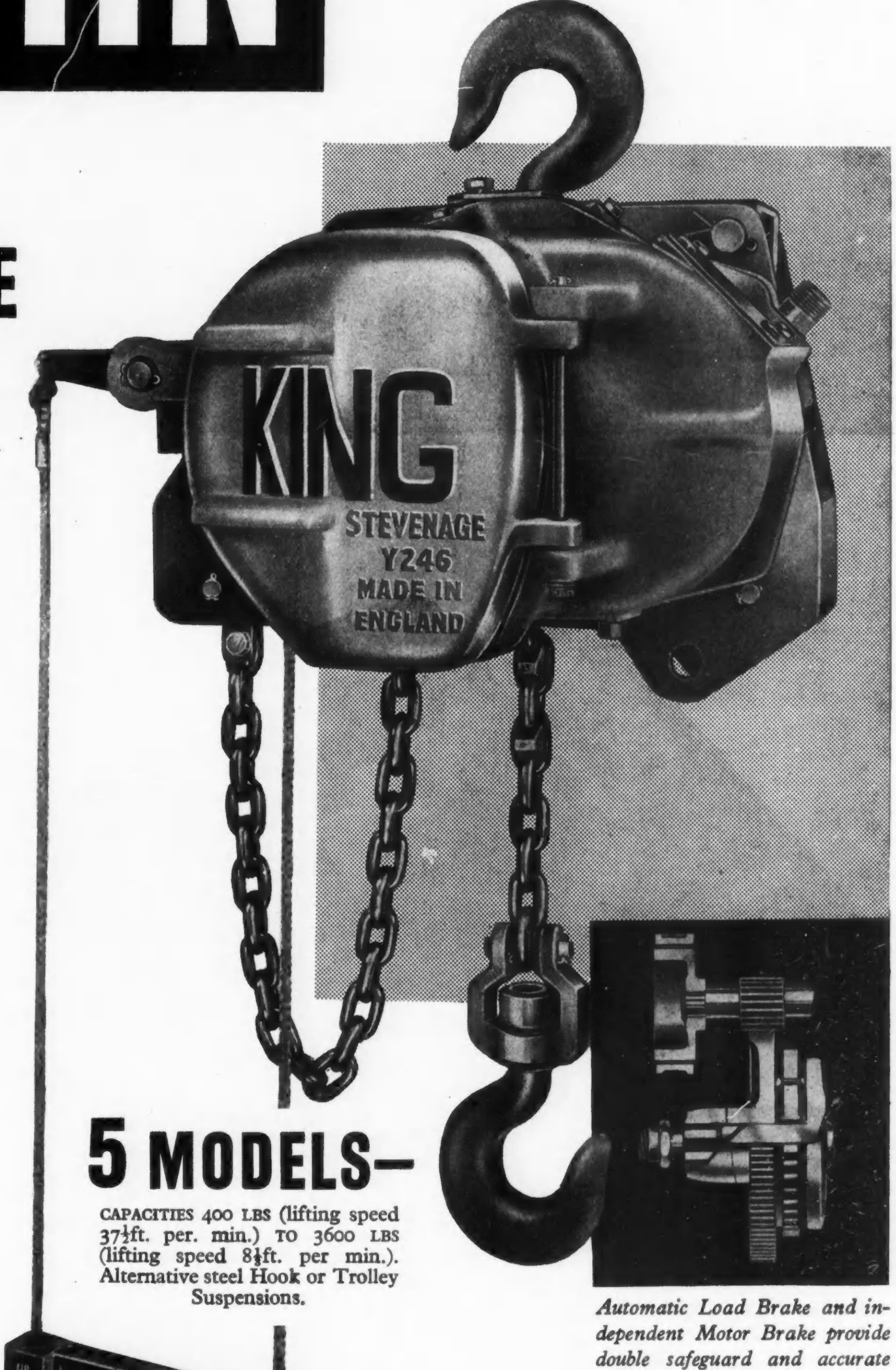

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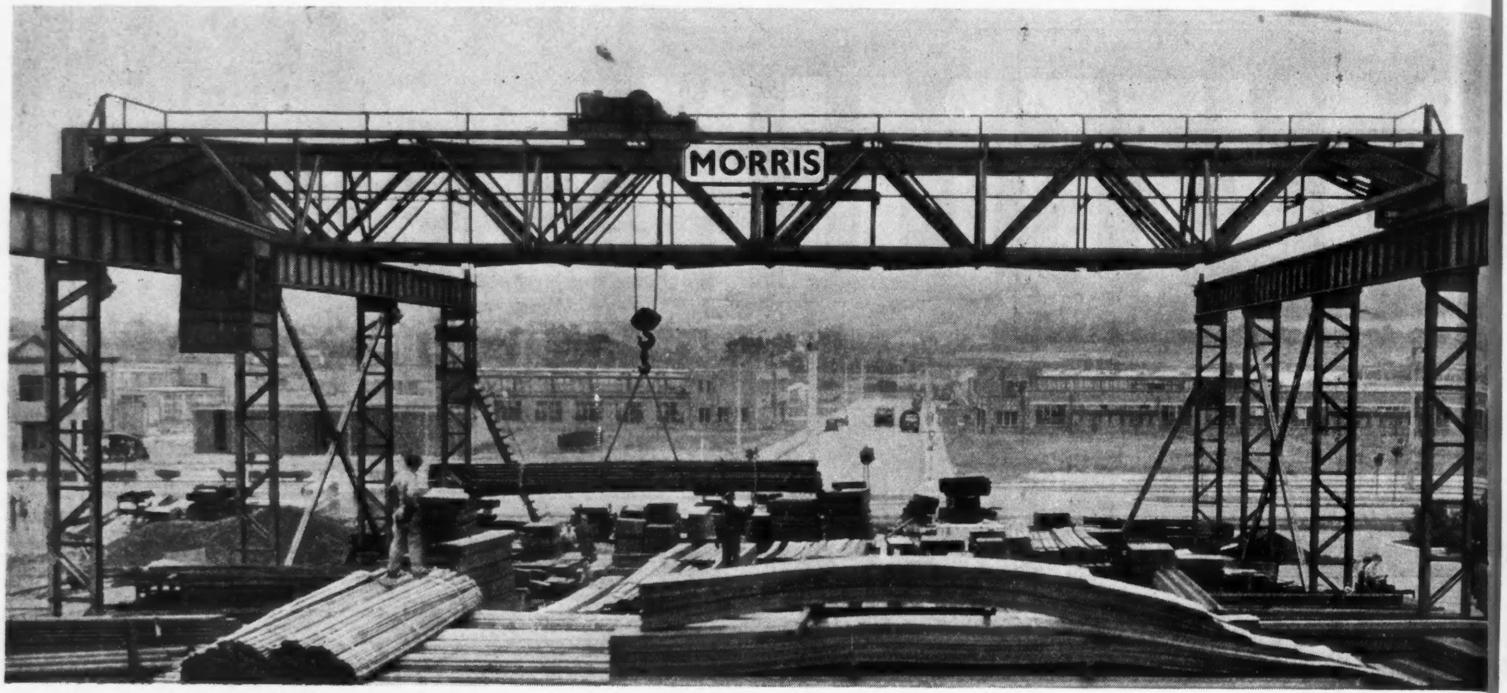

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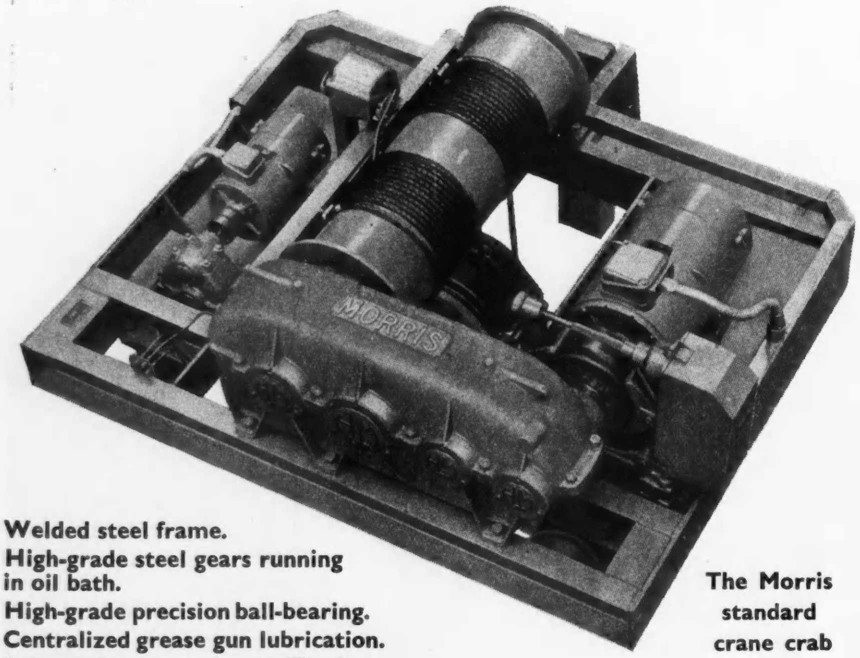

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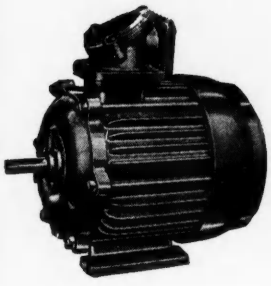

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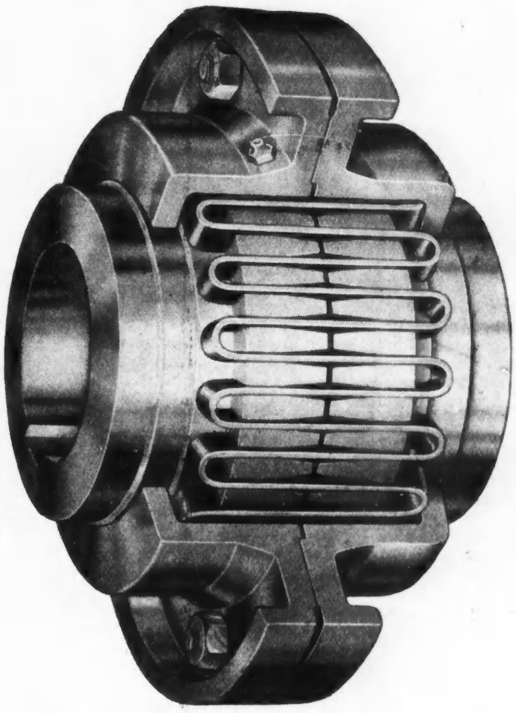

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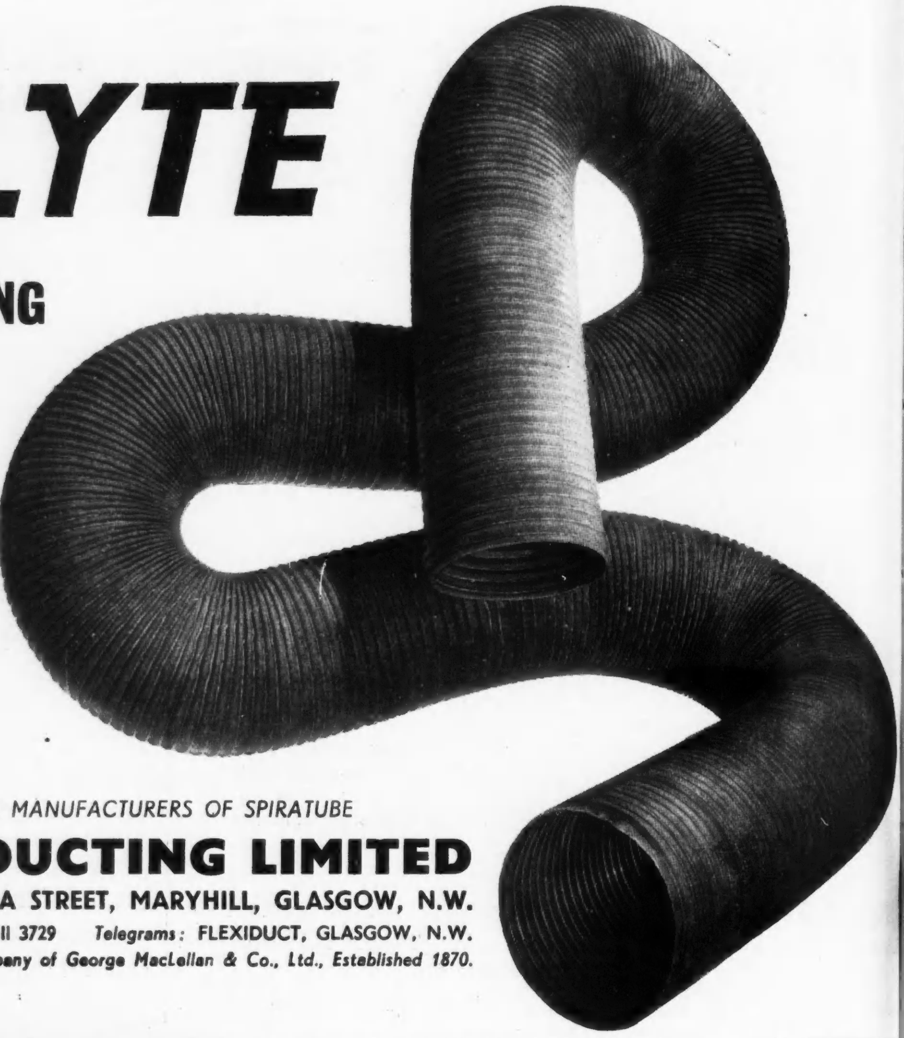

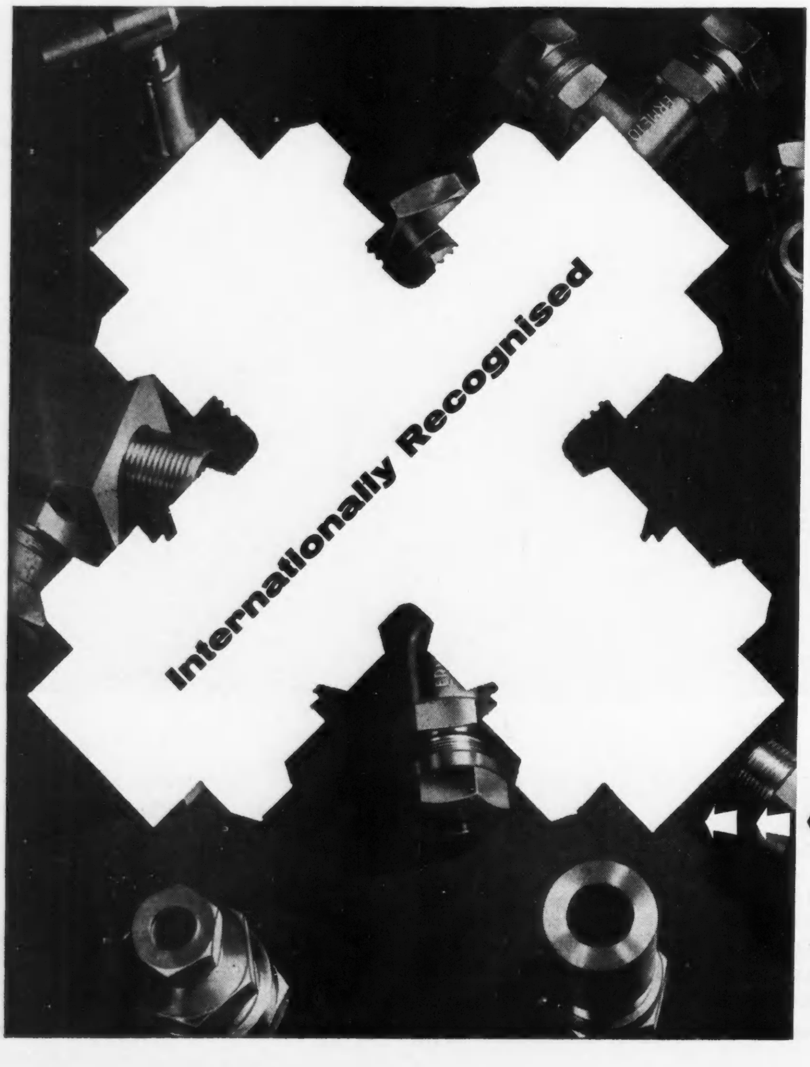

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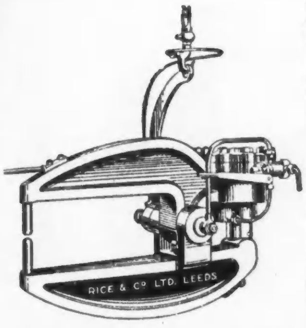

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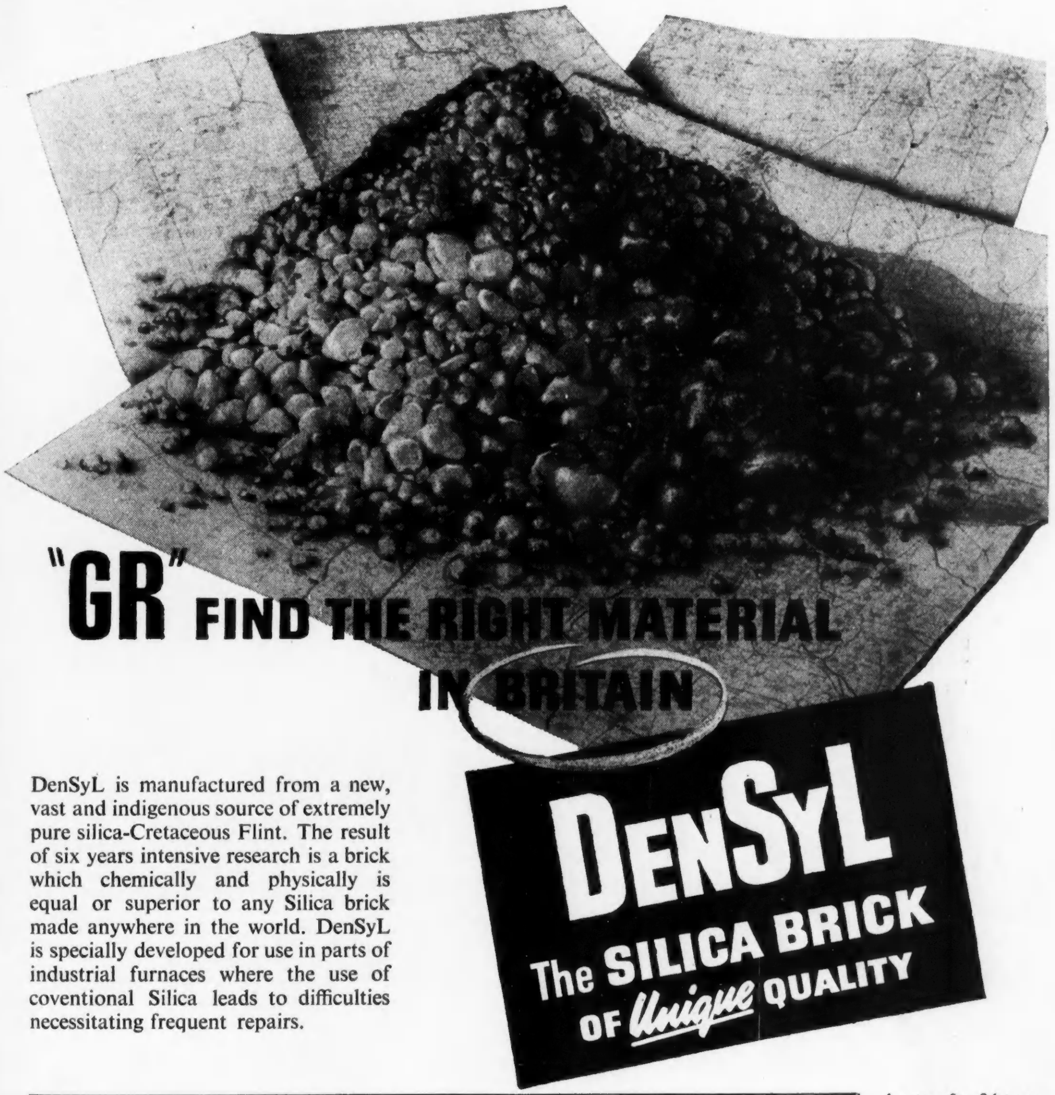

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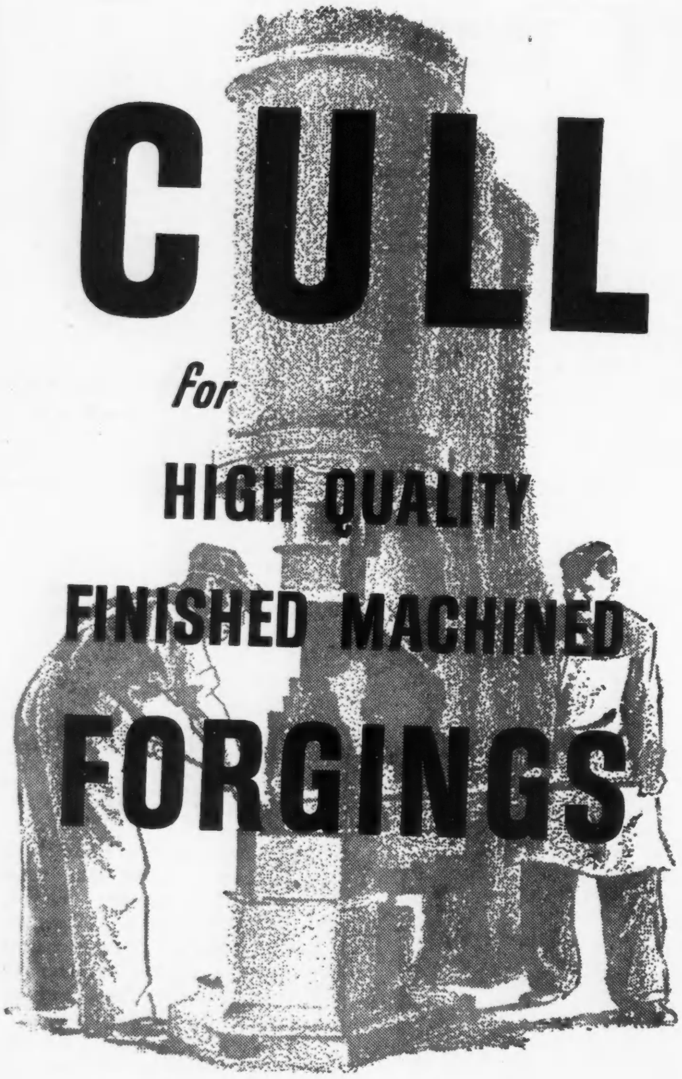

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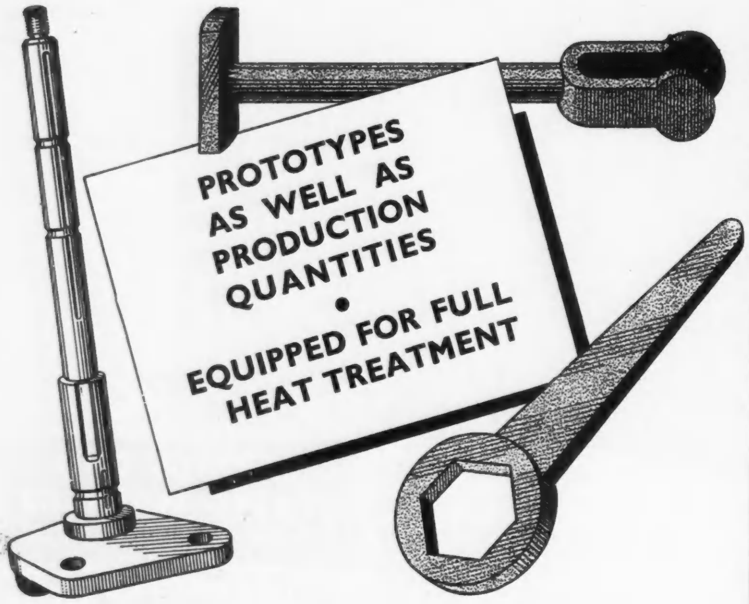

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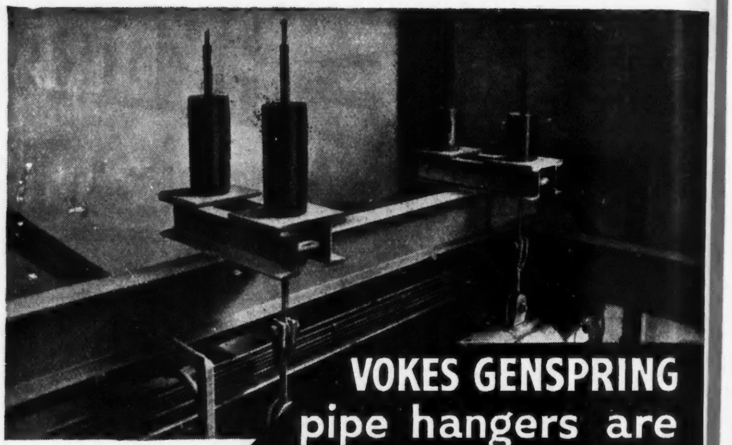

VOKES GENSPRING pipe hangers are used throughout the oil industry

Photograph by courtesy of The Associated Ethyl Company Limited.

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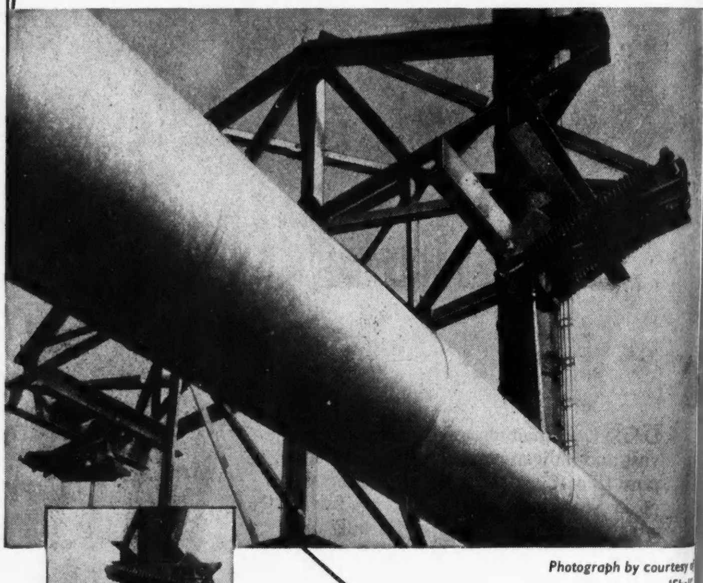

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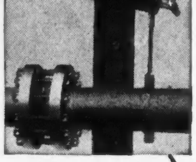

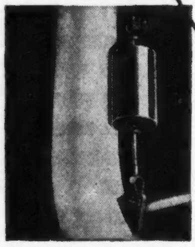

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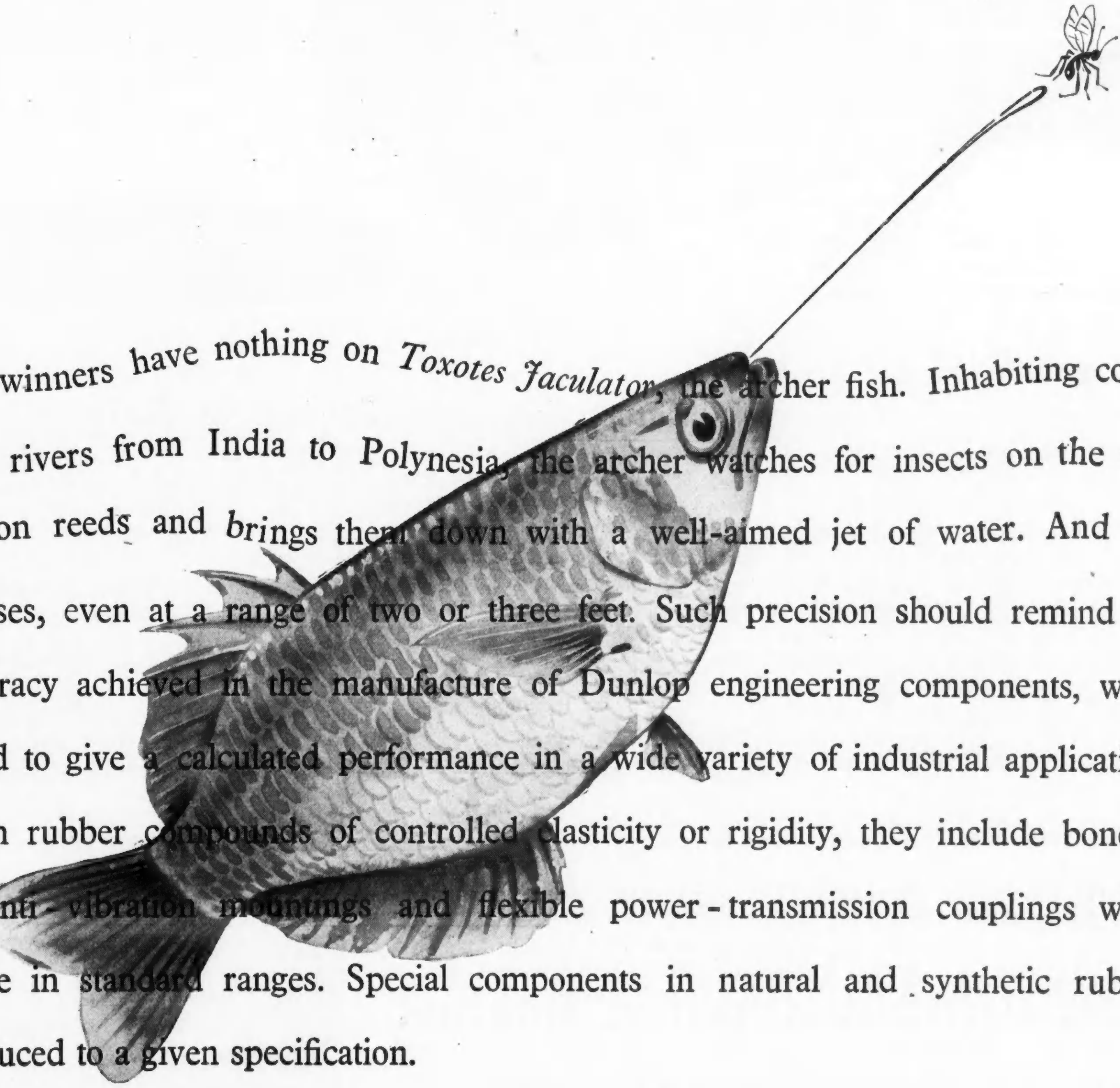

Bisley Cup winners have nothing on *Toxotes Jaculator*, the archer fish. Inhabiting coastal waters and rivers from India to Polynesia, the archer watches for insects on the wing or resting on reeds and brings them down with a well-aimed jet of water. And very seldom misses, even at a range of two or three feet. Such precision should remind you of the accuracy achieved in the manufacture of Dunlop engineering components, which are designed to give a calculated performance in a wide variety of industrial applications. Produced in rubber compounds of controlled elasticity or rigidity, they include bonded-to-metal anti-vibration mountings and flexible power-transmission couplings which are available in standard ranges. Special components in natural and synthetic rubbers can be produced to a given specification.

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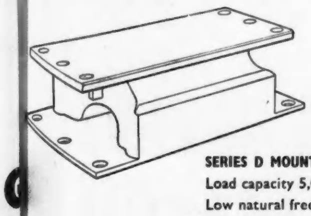

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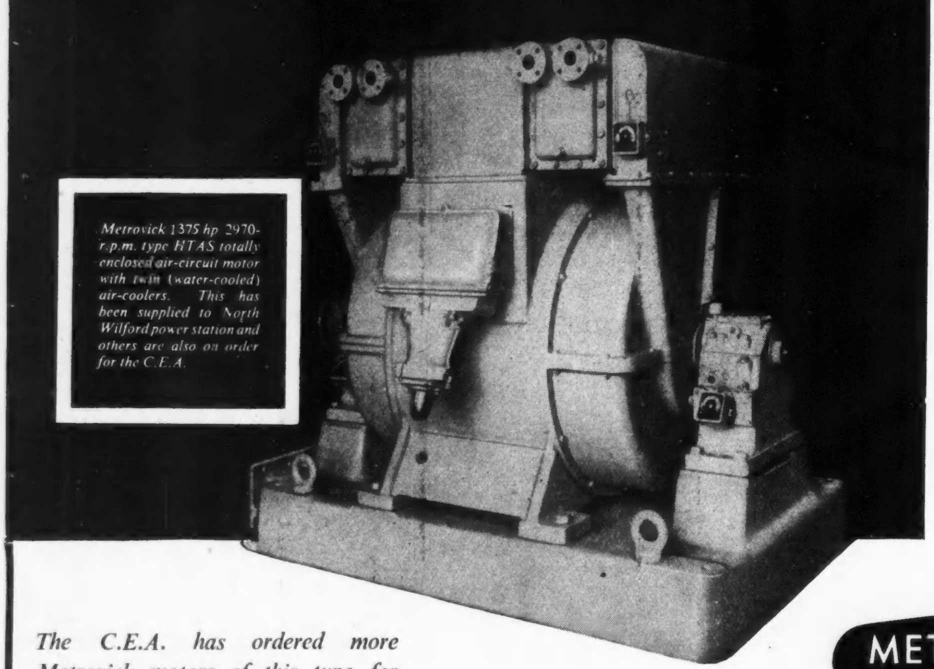

Metrovick 1375 hp 2970-r.p.m. type HTAS totally enclosed air-circuit motor with twin (water-cooled) air-coolers. This has been supplied to North Wilford power station and others are also on order for the C.E.A.

The C.E.A. has ordered more Metrovick motors of this type for use with 60 and 100 MW unit type boilers.

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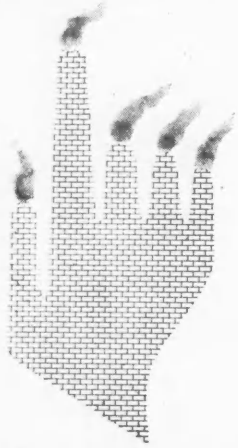

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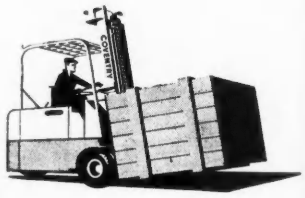

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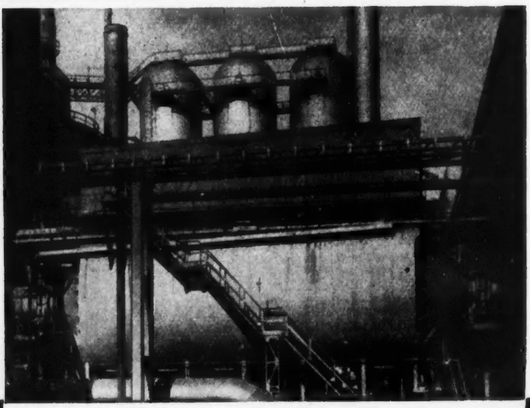

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THE ENGINEER

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AN EXPERIMENTAL COUNCIL

There still appears to exist in the public mind much puzzlement about the purpose of the new independent Council on Prices, Productivity and Incomes which the Government has just set up under the chairmanship of Lord Cohen and with Sir Dennis Robertson and Sir Harold Howitt as its other members. On the trade union side the T.U.C. regards the Council with quite deep suspicion. It took care to announce on July 24 that it "noted" the proposal of the Government to set up the Council and "noted" also assurances from Ministers that the body "will not interfere with the present system of collective bargaining or interfere in any negotiations or disputes in industry." It now appears rather to suspect that the setting up of the Council is an astute move on the part of the Government to put the T.U.C. in the wrong! It seems to think the Government, faced by the disapproval of the T.U.C., may be tempted to "score a point" by claiming that the unions are working against and preventing a solution to the problem of combating inflation. We hope it will do no such thing. It was, of course, hardly to be expected that the unions, very jealous of their individual right to indulge in wage bargaining, would offer any support to a body, however constituted, which might prove critical of that right. But even amongst the ranks of business men and industrialists, who harbour no similar suspicions, there appears to be some bewilderment about the functions of the new Council, and no warmth of welcome for it. It is accepted that there is strong controversy within the country and particularly between the main political parties about the actions that ought to be taken to combat inflation. But what, it is asked, can a Council without executive powers, whose advice the Government is not bound to follow—a Council, indeed, which will report to the public and not a Minister—achieve towards stilling the controversy? Is not the controversy a political one unresolvable in any but a political way?

Engineers, rather better than other men, perhaps, can see what may be in the Government's mind. For it is one of the advantages of an education in science that when a controversy arises the man thus educated seeks first and foremost to have the facts set out clearly and unemotionally before him. Nor are engineers likely to be upset by arguments that the economic facts are already as well known as they could be. Many a professor or research worker has been told before now that a proposed research is quite worthless as there is nothing further to discover; only to show later, by examining the problem with cold-blooded scientific precision, that a great deal did remain in fact unknown. Of course, it is one thing to conduct a research into a natural phenomenon and quite another to inquire into the workings of an economic system. Yet it seems to us that there is some parallel. When a natural phenomenon is investigated it can be confidently asserted that, given time and sufficient exertion, apparently contradictory facts, and the conflicting hypotheses founded upon those facts, can be reduced to order. Even if the effort involved is too great for any immediate solution to be found it will often prove possible, within a limited range, to establish "rule of thumb" formulæ enshrining, to a close approximation, the observed facts. No such formula, of course, is likely to be derived by the new Council to guide politicians as to what they should and should not do within an economic system. For, though economists sometimes write and talk as though human beings ought to be made to fit into the workings of some "orthodox" economic theory, in fact, if the theory leads to widescale hardship people will refuse to act in the way the theory assumes they ought to act! According, for example, to the orthodox economists of the beginning of this century, the right and, indeed, the only answer to this country's present-day economic problems would be the imposition of a swingeing deflation. The consequent large-scale unemployment and industrial depression would be regarded by them, were they alive to-day to impose the deflation, as the inevitable and unavoidable consequence of the operation of economic "laws." To-day, any Government which attempted to apply such a remedy would very quickly be thrown out of power. For having learnt by harsh experience between the wars, we now regard full employment and a steady expansion of output as more important to the welfare of this country than a pound sterling which can confidently "look the dollar in the face," or even a pound sterling that retains a steady level of purchasing power. But having made that decision we also want to know whether it is inevitable that full employment shall be accompanied by a fall in the purchasing power of the pound and, if so (as some economists appear to expect), how the rate of inflation should be controlled and how hardship to that proportion of people who live on fixed incomes can be avoided.

Now it is just around those questions that political controversy rages. On the one hand, trade unions wish to retain both full employment and individual power to force up wage levels. They object to many of the deflationary actions of the Government designed to mop up excess purchasing power, making those actions, indeed, the excuse for still further increases in wage claims. On the other hand, industrialists wishing to raise productivity, partly as an answer to increases in wages, object to Government restrictions upon capital expenditure. One party holds that unduly high profits are being made and that were they reduced prices could be held stable, the other declares that to finance capital expenditure profits must be high and that it is steadily increasing wage rates that are inflating costs. Both sides, perhaps, would prefer to see inflation continue, providing it is controlled, than adopt what might prove an uncomfortable alternative. But unfortunately, no man connected with a political party, least of all a member of the Government or a leading member of the Opposition, however coldly he marshals his arguments, can carry conviction on economic matters to those of opposite political complexion. Yet surely it should be possible coldly to marshal at least some of the facts, and to draw conclusions from those facts. No more is demanded of the new Council, we imagine, than that it should marshal the facts and that it should point out in its impartial conclusions what seem to it the inevitable consequences of adopting alternative economic policies. It will not be for the Council, of course, to choose what policies should be adopted. That is and must remain the prerogative of whatever Government is in power. But we see no reason why the Council should not be able clearly and impartially to lay before the public what the alternative policies are and what their consequences will be. The men composing the Council, though perhaps rather elderly—we should have preferred to see a Council composed of younger men who, over a term of several years to come, could establish themselves securely in the confidence of the public, Socialist and Conservative alike—are all noteworthy men capable of dissociating themselves from any political preferences in studying the questions they have been set up to examine. The experiment of setting up such a body is a novel one. It will be interesting to see whether it proves a success.

SOIL MECHANICS CONFERENCE

Soil mechanics has only quite lately laid claim to being a science. Its elevation to that state is indeed so recent that workers developing the science in laboratories and engineers applying it in the field still feel a particular excitement at an opportunity to tell others what they are doing, what they aim to do and what they have discovered. This excitement is lending atmosphere to the conference hall at the Institution of Civil Engineers, where, during this week and next, the papers of the fourth international conference on the subject, which have already been published in two weighty volumes, are being discussed at the various technical sessions. Progress is still rapid in this new science and in its application. An American firm has made a survey which points out that in 1949 there were only about 400 laboratories throughout the world which were concerned with commercial testing in soil mechanics. To-day there are about 5000! Soil testing is becoming a standard practice everywhere, it is asserted.

The Engineer

100 Years Ago

(AUGUST 14, 1857)

"WESTMINSTER BRIDGE"

"Poor old Westminster-bridge, health and happiness to you, and may you never know the want of them! After being pinned, and centred, and shored up in all conceivable ways, more than once threatened with an entire overthrow, and after having your top-hamper removed so that your hoary old crown might be kept just above water you are at last pronounced, really by the 'highest authority,' to be good to the core, and only to require a very slight change of medicine to that prescribed for you some time ago by our friend Dr. Page. . . . Perhaps the worst part of your case was when you refused to stand upright after having your pins strengthened and made wider so as to give you a better foundation. Remember that this cost your sorrowing country upwards of £80,000; and no sooner was it expended than down you went again as before.

"After remaining thus for some years, with one foot in the grave, you were considered so ugly that it would be necessary to give you a new suit from top to bottom. Instead of being humped back, you were to be made nearly flat, and instead of crossing the river in thirteen or fourteen steps you were to do it in seven. . . . Two eminent physicians were called in, and pronounced you an incorrigible old spendthrift, and that it would be better to get some foreigner to say to what place you had better be removed. . . . After thinking the matter well over, John Bull has decided to do just what we advised him, namely, to let you remain where you are. He has called in the 'highest authority,' who has pronounced that you have not yet lost all sense of decency, and from a careful examination of such portions of you as have been renewed, he is of opinion that you will yet live to ornament society. It is now, therefore, recommended that you be treated in conformity with the views of your own doctor, and be renovated forthwith. So now, at last, we trust you will be placed upon a secure footing, and that you will, when cured, exist for some years at least without giving any cause of alarm to your numerous friends."

As to the science itself, progress and interest is such that the organisers of the conference have had to "ration" the various national committees and thus limit the number of papers presented. One admirable result of this policy is that the papers are noteworthy, almost without exception, for their conciseness and brevity. They give an impression of considerable progress, particularly in the solution of detailed problems, but of no recent revolutionary step forward. One of the general reporters points out that soil mechanics is "passing from the applied technical state to the group of pure sciences." That is to say, there is increased emphasis on the "pure" science, and on its relationship with physical chemistry, geology and pure and applied mechanics. Basic data are still being collected about the physical properties of predominant "soil" materials in different parts of the world; and various theoretical problems are being reduced to tractable conditions of analysis. The science is still, however, in a position to give complete mathematical analysis of only the simplest cases in engineering design. One general reporter, after perusing 200 papers, remarks that "the nature of soil is simple compared with the procedure which men have devised for its treatment." Much, obviously, still remains to be achieved.

Since the Institution of Civil Engineers is acting as host to delegates from about forty countries, the achievements of British workers in this science will be of special interest. The British contribution is a strong one, even judged by the high standards of the contributions from other lands. Apart from the papers, some of this country's activities and achievements in soil mechanics are to be seen in the exhibition at the Institution, which has a great deal of technical interest to show. The present state of soil mechanics can be well illustrated to readers at home, by reference to one or two of the subjects which British authors chose to dilate upon. We find, for instance, a paper on the engineering properties of chalk, one of the commonest "soil" materials, yet almost no data about its properties as a foundation stratum had previously been published! There are also surveys of the behaviour of London clay, which is now becoming well understood; they include a paper on the stability of natural slopes, the critical angle for the stability of which in London clay is about 10 deg. These, of course, are facts picked out more or less at random from an exhaustive collection of papers which, altogether, present a very valuable review of recent trends and achievements in the more theoretical science of soil mechanics, as well as its practical application in foundation engineering.

WORK OF THE D.S.I.R.

Part of the Report for the year 1955/56 of the Department of Scientific and Industrial Research, which lies before us as we write, is valedictory. For on November 7, 1956, the Advisory Council, which for forty-one years has reported annually to the Committee of the Privy Council for Scientific and Industrial Research, ceased to exist. As, however, it was immediately replaced, under an Act of Parliament passed in August last year, by an executive body entitled the Research Council, which has much the same membership, continuity has been preserved and it can reasonably be expected that future Reports will look very similar to those to which we have become accustomed. The change, subject, of course, to the overriding responsibility of the Committee of the Privy Council, gives the new Council executive control of the Department; that is, it will now be able, if it is ever felt necessary, to instruct a director of a research establishment within the Department to develop particular work more rapidly or to close down researches felt to be unprofitable. In fact no doubt such matters will be settled, as before, mainly by discussion. The alteration is no doubt an outcome of experience of the work of the Council. It is also, to quote from the Report, " a reflection of the necessities for an organisation which has grown to a size probably exceeding the expectation of most, if not all, of its most enthusiastic founders."

The only other comment upon a Report, which in other respects is very similar to those that have preceded it, arises out of the accounts. In accordance with the five-year plan the expenditure of the Department upon research activities continued to rise during the year. But, though more than £2,000,000 was made available for new building construction some economies had to be made, with the consequence that the programme of planned expansion had to be slowed down. The Council is at pains to point out that though disappointed by the delay, it does recognise how many other claims there are upon money and men and does accept that it cannot expect to see everything done which it believes to be fully justified as seen from its limited departmental standpoint. We, however, are not in the position of the Council. Often it has seemed to us that in trying to reduce Government expenditure the Treasury has adopted the simple but nevertheless fallacious principle of cutting down a bit on everything instead of following a reasoned plan. Research work has become so important for this country's well-being in its attempts to capture and hold export markets that we cannot regard economies in that field as justified.

A Seven Day Journal

International Soil Mechanics Conference

The International Society of Soil Mechanics and Foundation Engineering is at present holding its fourth international conference at the Institution of Civil Engineers in London. During the course of this week, technical sessions have been in progress at the Institution building, together with those various other visits and social functions which customarily form part of an international gathering of this nature.

The congress was opened last Monday afternoon by Sir Arthur Whitaker, president of the Institution, who delivered an address of welcome to the delegates. The president of the international Society and also of the congress, Professor Karl Terzaghi, then delivered a lecture, during which he recalled his years of early experience as a civil engineer in the first decades of this century. At that time he attributed the prevailing ignorance about foundation problems to lack of systematic geological knowledge. Dr. Terzaghi went on to explain that he spent much time collecting geological data from a large number of constructional sites, but all this work achieved practically nothing. Several years later, however, he re-examined the records which he had accumulated, and concluded that the basis of classification of the various " soils " was inadequate ; that conclusion formed the starting point of his contribution towards the establishment of the science of soil mechanics as we know it to-day.

The conference will be in session until Wednesday August 21. Visits to places of either technical or cultural interest within easy reach of London have been arranged during the period that the conference is in session, and it will be followed by tours of Scotland and in East Anglia. An exhibition of civil engineering topics especially related to soil mechanics is also on view in the Institution building.

London Transport

The review of the work of London Transport for 1956, which has been produced primarily for the senior staff of the organisation, shows that during the year its road and rail services carried just under 3914 million passengers as compared with 4905 million in 1955. This drop of some 4·4 per cent occurred entirely on the bus and coach services and outside the peak periods. It is attributed to growing competition from privately owned motor cars and the increasing numbers of television sets which reduced the call for public travel to places of entertainment. The net receipts from traffic and other sources increased by some £4,500,000, but this fell short of the rise of £4,900,000 in working costs for the year.

As in the review for the previous year attention is drawn to the increasing effect private motoring is having on the public transport system. It is pointed out that by the Summer of 1956 one in every three and a half households in London possessed a car, and it is estimated that nearly half the net fall in passenger miles in the London Transport area between 1950 and 1955 might be attributed to the growth of private motoring. The review again draws attention to the serious effect street traffic congestion had on the regularity of road services. It points out that the reduction in congestion brought about by fuel rationing with the Suez emergency at the end of the year confirmed what London Transport had been saying for years about the effect that road congestion had on public transport services. The reduction in traffic brought about by fuel rationing showed that London buses and coaches could be fully self-supporting and provide regular efficient services. The difficulties of providing for rush hour travel in London were, it is stated, likely to be intensified with the new office development in progress. Staggering of working hours is considered to be the only rational and economic solution to this problem.

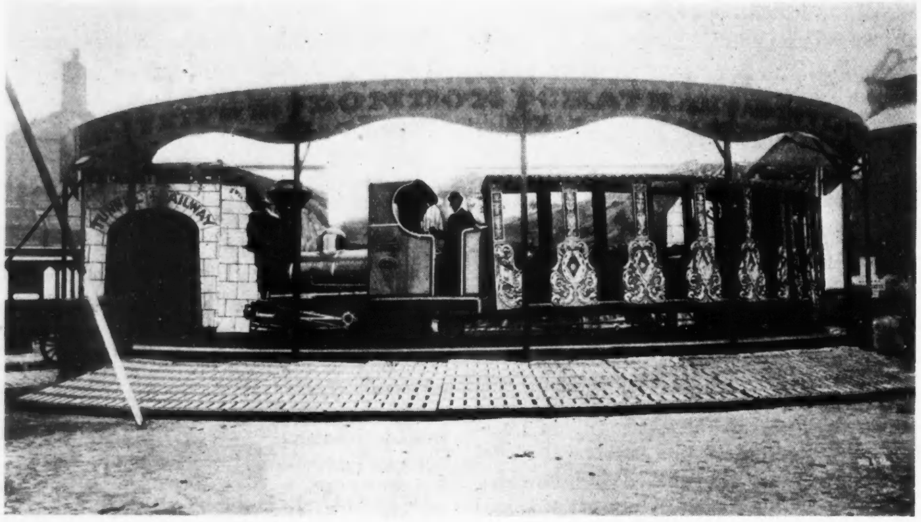
School of Welding Technology

The establishment of the School of Welding Technology was announced on August 8. At a conference of which the chairman was Sir Charles S. Lillicrap, president of the Institute of Welding, a brief talk on the needs of the industry was given by Mr. A. Robert Jenkins, past president of the Institute. This was followed by some details of the present and future organisation of the school, given by the secretary, Mr. G. Parsloe.

The formation of the school is the outcome of discussions between the Institute of Welding and the British Welding Research Association. It has been decided to discontinue the summer school hitherto organised by the B.W.R.A. at Ashorne Hill and undertake a more ambitious educational programme through the medium of the new school. Intensive specialised courses lasting one week each are to be given monthly in London throughout the year. Not more than forty enrolments are to be accepted per course, but about a third more students will be received annually than could be taken at Ashorne Hill. The prospectus is designed for technologists with industrial experience and responsibility.

There were shop floor problems throughout the country, said Mr. Jenkins in his introductory address, and they were often dealt with by an individual rather nebulously appointed as a " welding engineer." There was a serious need for education, especially of a rather more advanced kind, and although this country was not behind others in technique, there was a lag in application. Mr. Parsloe amplified this by pointing out that university and technical colleges do not—in fact, cannot—provide the intensive form of instruction required by responsible persons in industry. Only four nights need be spent in London by students taking the new courses, or five for those living north of Manchester. The syllabus was designed to evolve according to changing need and demand. There were to be no examinations, and no certificates would be issued. In the longer term it was hoped that the Institute would be able to provide a full-time school on an altogether larger scale ; meanwhile the response to the present undertaking would show whether such ambitions might be capable of fulfilment.

Copies of the prospectus are available from the School of Welding Technology, Institute of Welding, 54, Princes Gate, London, S.W.7.



Fairground Tunnel Railways

By R. A. S. ABBOTT*

No. II—(*Concluded from page* 191, *August* 9)

When the fascinating subject of fairground machinery was so ably dealt with by Mr. P. W. Bradley in THE ENGINEER *during 1954, brief mention was made of that rare form of " ride," the circular tunnel railway. These railways were never very numerous and only about fifteen are known to have been operated by showmen in Great Britain. This article traces what is known about them, and, in particular, the peculiar locomotives used on them.*

BEFORE leaving the subject of Savages' locomotives mention must be made of a proposed design for an eight-wheeled engine. This locomotive (Fig. 6) was basically similar to that illustrated by Fig. 4, but all the wheels (on each side) were of the same diameter, although only the second pair from the front were the drivers. The dimensions of this locomotive, scaled from the incomplete drawing, were: length of frame, 12ft 6in; wheelbase, leading to driving axle, 4ft 6in; driving to third axle, 3ft 3in; third axle to fourth, 3ft 3in; total, 11ft. All wheels on the side shown were 1ft 4in diameter; length over boiler barrel and firebox-5ft 5in; diameter of boiler, 2ft 2in; length of smokebox, 1ft 1in; dome cover, 1ft 3in diameter by 1ft 6in high; top of boiler from rail level, 3ft 10in; height of cab roof from rail level, 4ft 10in; height to top of chimney from rail level, 6ft 9in. There is no evidence to prove that such an engine was ever built, although the original undated drawing is marked " Dodworth, Barnsley," and this, together with the name " Conqueror," would seem to indicate that the project reached an advanced stage.

The second firm to cater for this new addition to fairground attractions was John Fowler and Co., Ltd., Steam Plough Works, Leeds. Three sets were built, the first in May, 1895, to the order of Mr. J. W. Waddington, of Leeds. This railway (Fig. 7) was not a very elaborate or ornate affair, but the locomotive (Fig. 8), bearing works No. 3688 and the name " The Pioneer," was quite an attractive little machine of the 0–4–2 side-tank type with outside cylinders, 4in diameter by 7in stroke, and fitted with single slide bars of round section. The valves, on top of the cylinders, were operated by rocking shafts, and reversing gear was provided, judging by the rod leading back to the foot-plate. The steam dome was encased in strips of polished wood and the coal or coke was carried in side bunkers. Brake blocks operated on the rear driving wheels. The photograph reproduced in Fig. 7 was taken at a Leeds fair in June, 1895. In September, 1895, another railway was delivered to a Mr. Burke, of London, and in this we see a much neater and more advanced layout, the carriages being highly decorated, as shown above. The locomotive was again of the 0–4–2 outside cylinder type, but with outside frames. The works number was 7528 and it bore the name of " Nockalong." The cylinders, 4½in diameter by 8in stroke, had the valves on top, actuated by the outside link motion with the eccentrics mounted on return cranks. No slide bars were provided, but the piston rods worked in long bushes carried by brackets. The gauge was 2ft. The general design of this locomotive, combined with a large headlamp and spark arresting chimney, resembled many of the engines supplied overseas by Messrs. Fowler for plantation work. This railway was first operated at Woodhouse Feast, Leeds, on September 20, 1895. It was afterwards sold to Mr. J. P. Horneng, in May, 1898. A similar set was built for Richardson Brothers, of Darlington, in December, 1895, the locomotive being works No. 7529, and named " Pride of the Tyne." The photograph reproduced is the only official record that now exists, and from it it is not possible to detect to what extent these locomotives were built " on the curve "; all drawings were destroyed during 1939–40.

Although of no technical interest, the wide gap between the works number of the locomotive built in May, 1895, and the ones built in September and December, 1895, will be noticed, and this is explained by Fowler's practice of allocating works numbers in batches: six for locomotives, twenty-four for ploughing engines, and twelve for traction engines and rollers, and in many cases as long as ten to fifteen years elapsed before a series was used up, although new series of higher numbers had been started years before. Historians would do well to bear this practice in mind when any attempt is made to date a Fowler engine from its known works number.

Another famous Leeds firm, Thomas Green and Son, Ltd., Smithfield Ironworks, built three tunnel railways during the year 1895. The first of these was to the order of Mr. W. Murphy, in November (works No. 214), and through the courtesy of Mr. R. H. Clark it has been possible to illustrate it in Fig. 11, which has the look of being an official photograph, perhaps taken at the first public appearance at a fair. The locomotive, of the 0–4–2 tank type, had outside cylinder, 4½in diameter by 8in stroke, with single slide bars, and the valves, on top of the cylinders, were operated by rocking

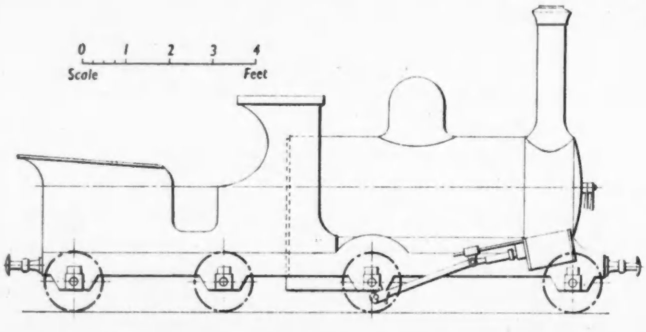


Fig. 6—Proposed design for eight-wheeled locomotive by Savage Bros.

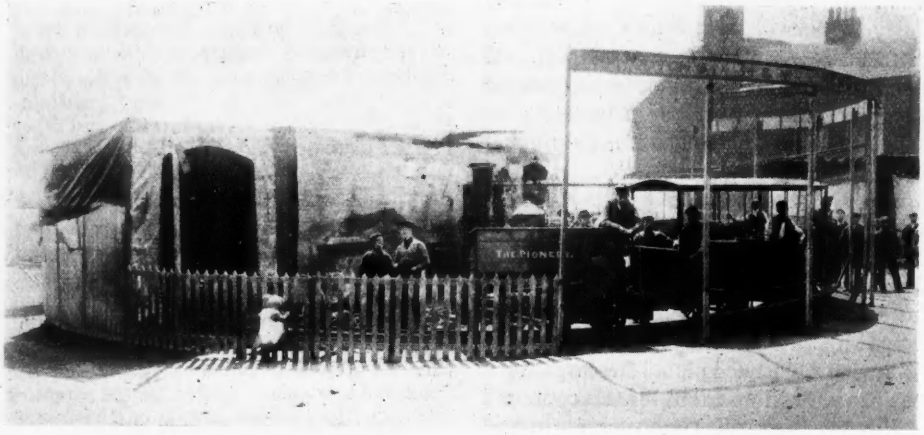


Fig. 7—Tunnel railway built by John Fowler and Co., Ltd., in May, 1895, for J. W. Waddington, Esq. This photograph was taken at a Leeds fair in June, 1895

shafts. The front axle was provided with half-elliptic springs, but whether the driving axle had similar springs is not known. This engine carried two plates, a nameplate on the smokebox side, "Selina," and a plate with the motto "Fear No Foe" on the cab sidesheet.

Two Continental showmen ordered identical sets, one being supplied in the same month to a Herr Leeser (Germany), Works No. 216; and a third, Works No. 217, went to a Herr Siebold (Germany). The track gauge of all three lines was 2ft 6in. For the above particulars the author is indebted to Mr. W. A. Owen, Chief Designer at the Smithfield Works, but no other details are available as the rest of the records relating to these railways have been lost or destroyed.

The locomotive examined by the author in Berkshire during 1952 was quite different in general design from any of those previously described, as will be seen from the right- and left-hand views, Figs. 9 and 12.

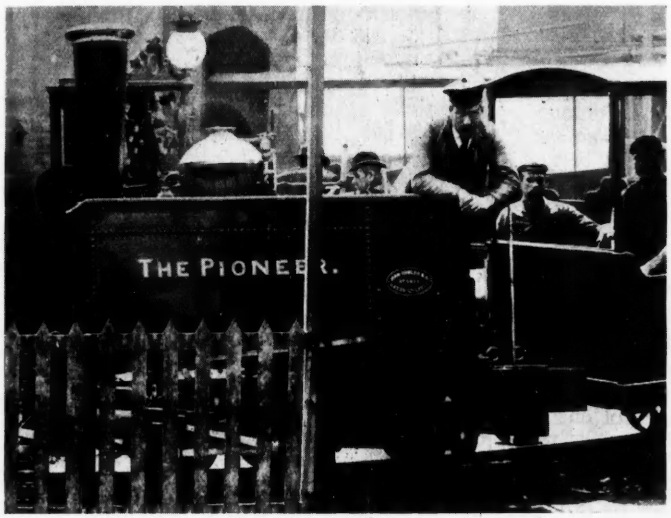


Fig. 8—0-4-2 tank locomotive, "The Pioneer," built by John Fowler and Co., Ltd., in May, 1895

The cylinders were 5in diameter by 10in stroke, with single slide bars, and the valves were operated by rocking shafts from inside eccentrics; no provision was made for reversing. Driving wheel diameter, 17in on the outer rail, 14in on the inner. There were no springs. The boiler had thirty-six tubes of 1¼in diameter. Length of frame on outside of curve, 8ft 4in; inside, 6ft 10in; width, 4ft; height to top of boiler from rails, 3ft 10in; height to top of chimney from rails, 6ft. The train ran anti-clockwise, and the side of the locomotive presented to the onlookers was neatly finished, the cab having a side panel and the boiler a handrail, but on the inside the running boards carried a water tank, the cab was cut away, and a large brake lever was screw operated. The back edge of the firebox was decorated with a broad band of brass, and the dome-cover was also of polished brass.

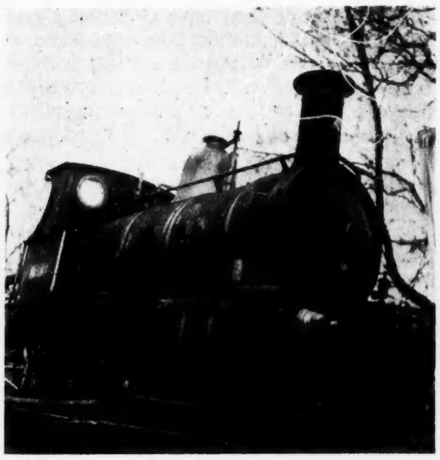


Fig. 9—Tunnel railway locomotive "Champion" at Twyford, Berkshire, in November, 1952, mounted on road wagon

The building date and maker of this locomotive is at present unknown, but through the courtesy of Mr. Stuart P. Johnstone some details of its past history can be briefly recorded here. It was originally named "Champion" and was owned by W. C. and S. Handcock, and at first ran on a track only 3in above ground level, as can be seen in the illustration, Fig. 10, which also shows how the coal was carried in a crude kind of separate bunker attached to the rear of the main frames; this fitting had vanished when the locomotive was seen in 1952. It was at Lawrence Hill and Old Haymarket Fairs, Bristol in 1893 and 1894, and was then bought by Jacob Studt, and travelled South Wales, but as it did not meet with much success it was sent to the works of Messrs. T. and J. R. Walker, roundabout builders, at Tewkesbury, for structural alterations. It was subsequently acquired by a Mr. S. White, who resold again to Messrs. Woolls of Kent, and it was seen in operation at Bostall Heath Easter Fair as late as 1929. There was a suggestion of bringing it back into commission during the 1939-1945 war, but this idea never materialised, and the locomotive and carriages eventually arrived at a dealer's yard in Berkshire where they were finally dismantled early in 1956.

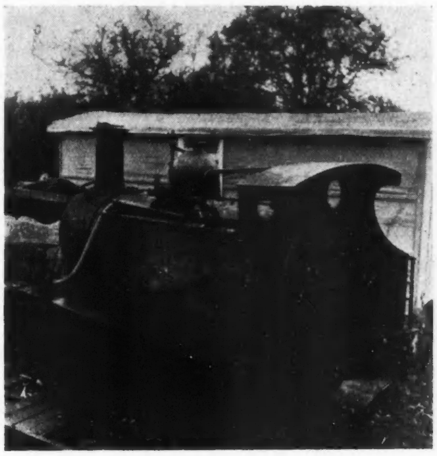


Fig. 12—Tunnel railway locomotive "Champion" at Twyford, Berkshire, in November, 1952, mounted on road wagon

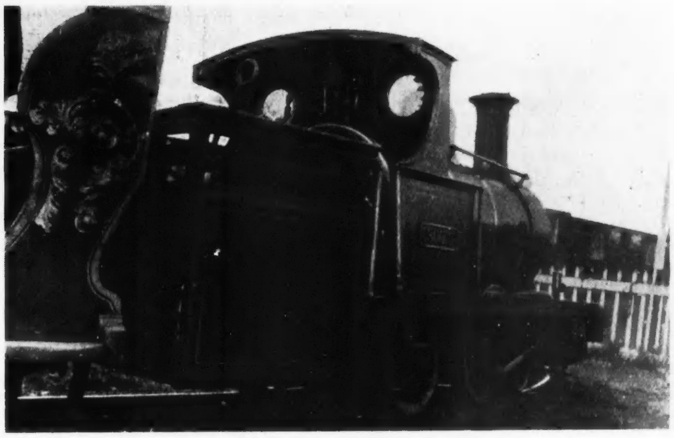


Fig. 10—2-2-2 Locomotive "Champion" as running during the 1890s on ground level track

Some locomotives for showmen are now known to have been built at the Castle Engine Works of W. G. Bagnall, Ltd., at Stafford, but unfortunately as they were not treated as normal locomotive construction, details of them do not appear in the firm's locomotive register. Careful search has failed to produce any drawings or records; there is however, a verbal tradition of their production which is supported by the personal recollections of Mr. W. C. Bostock of Tunbridge Wells, who was on the staff of the firm in 1896 and remembers seeing a 2-2-2 outside cylinder loco-

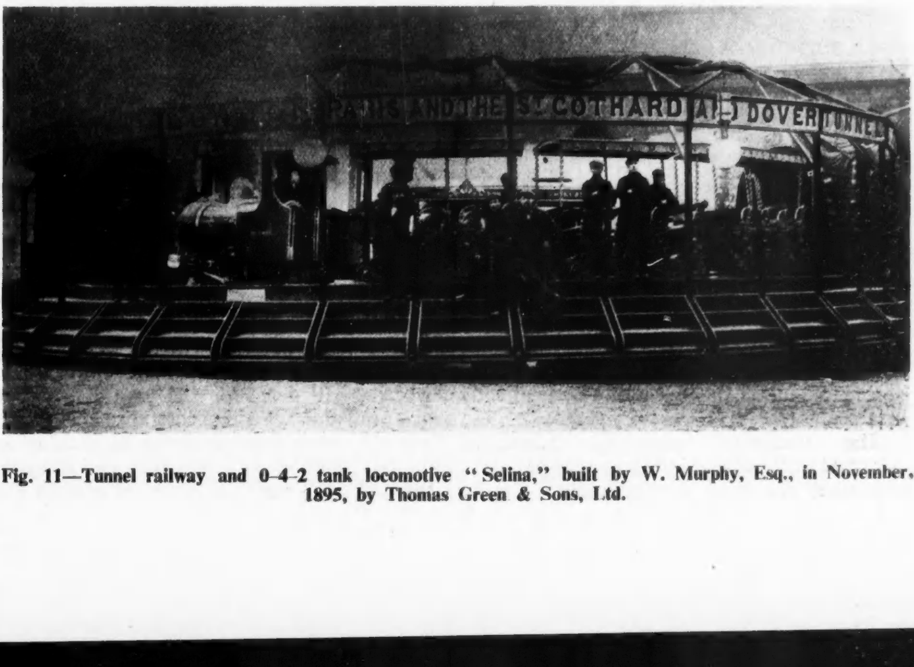


Fig. 11—Tunnel railway and 0-4-2 tank locomotive "Selina," built by W. Murphy, Esq., in November, 1895, by Thomas Green & Sons, Ltd.

motive, with radially set axles, being built.

As will have been gathered from the above account, fairground tunnel railways were never very numerous ; fifteen sets having been definitely traced, with the existence of two others remaining uncertain. The last of these railways to survive in service in Britain was Savage No. 643 owned in the nineteen-twenties by M. Jarvis, Chase Town, Staffordshire. It finished up at a permanent ground on the Lickey Hills in the early nineteen-thirties.

In concluding this unavoidably brief review the author wishes to express his gratitude for the valuable assistance given by Messrs. A. Pepper, of Leeds, W. A. Owen, Chief Designer at T. Green and Son, Ltd., Leeds, Stephenson Pilling, A. R. Johnson, managing director and works manager respectively of Savages, Ltd., King's Lynn, W. A. Smyth, managing director of W. G. Bagnall, Ltd., W. G. Bostock, of Tunbridge Wells and Stuart P. Johnstone, of Cheltenham. For the use of photographs and drawings acknowledgment is due to the following : Fig. 1 is by courtesy of the Controller of H. M. Stationery Office ; Figs. 2, 3, 4 and 6, Savages, Ltd.; Fig. 5, Locomotive Publishing Co.; Figs. 7, 8, and title picture on page 220, John Fowler and Company, Ltd.; Fig. 11, Mr. R. H.Clark, of Shotesham All Saints, Norfolk ; Figs. 9 and 12, Mr. J. F. Bruton of Fulham ; Fig. 10, Mr. F. Jones, London.

Load Distribution on Helical Gear Teeth

By DR. M. D. TRBOJEVIC, A.M.I.Mech.E.

No. II—(*Concluded from page* 190, *August* 9)

The aim of experiments carried out between 1953 *and* 1955 *in the Department of Applied Mechanics at the University of Sheffield, and at the Laboratory for Machine Members of the University of Belgrade, was to determine the deflection of a rubber tooth loaded along different lines of contact. Load distribution along lines of contact for various positions of the contact lines and for various helix angles was found. A method for determining partial loads acting on teeth simultaneously in contact was attained. Conditions were investigated under which the load distribution is most convenient and the position of the least favourably loaded contact line was determined.*

METHOD OF TESTING

FOR every contact line and for every chosen angle γ deflections under the empty pipes were measured. By "deflection" the ordinate of the deflection curve is to be understood. This ordinate is equal to the displacement of the observed point of the contact line of the loaded tooth relative to its position when unloaded. Deflections were then measured with loads of 10, 20, 30 and 40 balls. Differences in readings showed how deflections increased under the load applied. When these deflections were divided by respective loads, the characteristic of local flexibility could be obtained. These characteristics are straight lines (Fig. 13). The slope of each line represents the reciprocal of the corresponding combined stiffness C_t.

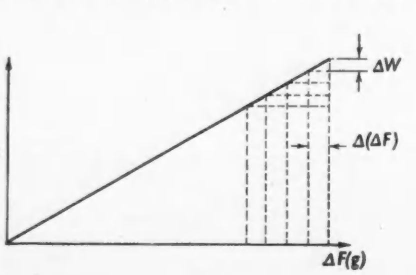


Fig. 13—Diagram to show local flexibility of tooth

If the values $1/C_t$ so obtained are multiplied by the total loads (the weight of the fully-loaded pipes), the total deflections at the point under observation can be obtained. The curve connecting the ordinates of the deflections so obtained is a deflection curve. When the corresponding deflection curves were added (when the gears are engaged this occurs simultaneously) it was observed that load distribution was not uniform, as already stated.

The maximum combined deflections occurred at the ends of the contact lines, their minimum occurring in the middle. Fig. 14 gives some indication of the results during this phase ; some of the results are also shown in Figs. 15 and 16. The circles in the diagrams denote the results of one series of readings and the points show the results of the other. Disposition of the specific loads is given in Fig. 10. The points of intersection of the lines given in this diagram show the positions of the axes of the pipes.

For a pair of similar teeth, similarly loaded, the load distribution curve must obviously be symmetrical about the mid-point of the contact line and the combined deflection must be the same at all points (Fig. 8). The load distribution required to fulfil these conditions was discovered by repeated trial for each of the selected lines. A loading scheme giving constant combined deflection is given in Table I. Fig. 17 shows the required load and partial and combined deflections.

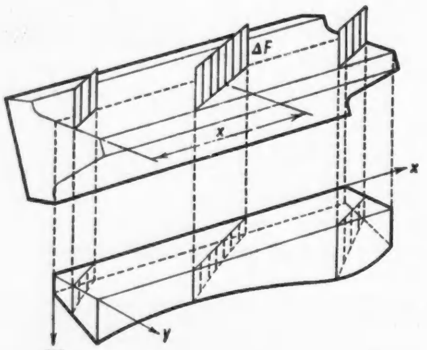


Fig. 14—Deflections caused by uniformly distributed load along a contact line for a given γ angle

TABLE I—*Loading Table Expressed in Terms of the Number of Balls which Should be Added at Each Subsequent Loading in Order to Obtain a Constant Combined Deflection Along a Contact Line*

Length of the contact line expressed by the number of pipes	Number of balls inserted at each subsequent loading
1	10
2	10 10
3	9 10 9
4	9 10 10 9
5	9 10 10 10 9
6	9 10 10 10 10 9
7	8 9 10 10 10 9 8
8 &c.	according to the scheme, 8, 9, 10 . . . . 10, 9, 8.

Fig. 18 gives deflections along contact lines when $\gamma=10$ deg., for the load distribution given in Table I. Each of the full-line curves in Fig. 18 corresponds to one of the loaded contact lines in Fig. 10. The deflection of the tooth at a point on a loaded contact line and distant x from the end-limit of contact, is represented by the ordinate of the corresponding full-line curve in Fig. 18 for the value of x concerned. All contact lines whose length is between 1 and 11 (the number denotes the number of pipes), on the left-hand side of the diagram, begin from the points 6mm from the edge of the tooth. It can be seen that the ordinates corresponding to these lines, for the same abscissa value, increase with the increasing length of the line, having their maximum for the line passing through the end limit of the tip contact. Going to the right, the other lines 11 (11(*a*), 11(*b*), &c.) have decreasing ordinates till their maximum falls approximately to 150 microns (0·001mm). The form of these lines then remains unchanged and they have the same ordinates. But coming nearer to the other side of the tooth, deflections

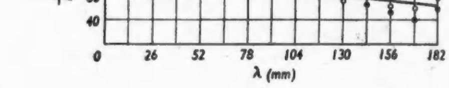


Fig. 15—Deflection curve under a uniformly distributed load (196·5 g/13mm) when $\gamma=5$ degree for position 15–15 (Fig. 10)). λ denotes the length of the contact line and W deflection

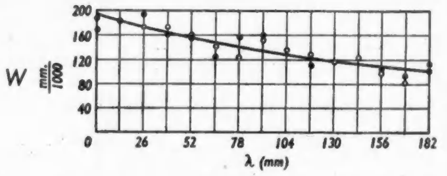


Fig. 16—Deflection curve of the uniformly distributed load (196·5 g/13mm) when $\gamma=5$ degree. Position 15′–15′ (Fig. 10)

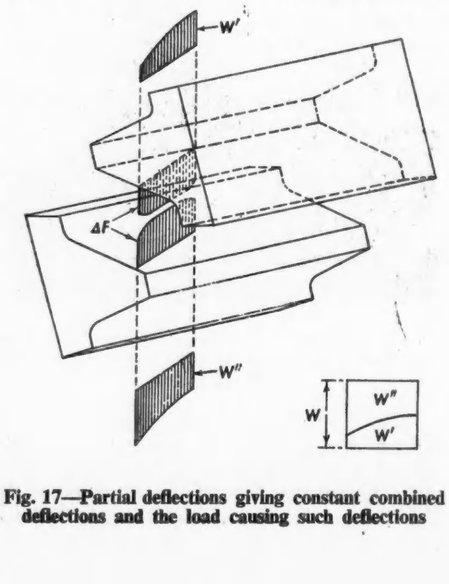


Fig. 17—Partial deflections giving constant combined deflections and the load causing such deflections

begin to increase. Maximum deflection on the right side corresponds to the lines 5′—5′ and 6′—6′ (Fig. 18). The curve connecting the maxima of the ordinates shows how the tip of the tooth deflects during loading; on both ends of the tooth there are parts which have local maxima.

Table II gives for each of a number of contact lines (*a*) the ratio of combined deflection to mean load per unit length, and (*b*) the ratio of local maximum load per unit length to mean load per unit length.

TABLE II—*The Ratio of Combined Deflection to Mean Load per Unit Length and the Ratio of Local Maximum Load per Unit Length to Mean Load per Unit Length for different Lengths of the Contact Line*

	Length of the contact line expressed by the number of pipes													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
$w/\Delta F_{mean}$	1·125	1·152	1·172	1·182	1·189	1·190	1·186	1·170	1·150	1·126	1·102	1·080	1·068	1·056
$\Delta F_{max}/\Delta F_{mean}$	1·000	1·010	1·015	1·019	1·021	1·022	1·022	1·022	1·020	1·018	1·016	1·014	1·013	1·012

The load distribution given in Table I will change if the faces of the teeth are mismatched, e.g. when the lengths of the teeth are unequal. Owing to the mutual change of the local stiffness of the mating teeth, it was necessary to renew the research for a load distribution which would give the same combined deflections along a whole contact line. The ratio between the maximum and the minimum load along a contact line was in this case greater than before, as could be expected. But, even now, in the most unfavourable case, the relation between the maximum and the mean load did not exceed 1·063. If it had been possible to use thinner pipes this ratio would probably have increased but even this value shows that such a position of the teeth is undesirable, so that an equal length should be used and gears so assembled as to have end faces matched. Otherwise, those parts of the teeth with least strength are exposed to the greatest loads. Pinions made, as they often are, with slightly longer teeth than the gears are by no means to be recommended, and may be regarded as faultily constructed.

ANALYSIS OF EXPERIMENTAL DATA

Table II shows that the load distribution along a single contact line is nearly uniform. Even in the most unfavourably loaded case, the excess of the maximum over the mean load does not exceed 2·2 per cent. This number was obtained when the maximum load 196·5 grammes was divided by 192·2 grammes, being the mean load of the contact line 7, where the greatest difference occurred. The load distribution could, therefore, be considered to be practically uniform. Without much error being introduced, it could be assumed, when the combined stiffness had been computed, that there was a uniform load distribution. For further computation it is more convenient to express the combined stiffness C_i by means of the total deflection. If the expression for the stiffness of a single tooth $C_i'=F_i/w_i'$ or $C_i''=F_i/w_i''$, were substituted in the expression for the combined stiffness, we should find:

$$C_i=\frac{C_i' \,.\, C_i''}{C_i'+C_i''}$$

$$=\frac{F_i^2}{F_i\,.\,(1/w_i'+1/w_i'')\,.\,w_i'\,.\,w_i''}=\frac{F_i}{w_i'+w_i''}.$$

The combined stiffness, as has been shown, is inversely proportional to the total deflection. When the force, acting upon the tooth flank at right angles, is divided by the sum of combined stiffnesses, the deflection of the system of engaged teeth is obtained.

$$w=F/C.$$

And by means of this deflection the partial load acting on each simultaneously engaged pair,

$$F_i=w\,.\,C_i.$$

For gears of various face widths and for subsequent phases of engagement the length of single contact lines were systematically measured. By dividing these lengths by the common outside diameter of the pipes, the number of pipes loading each contact line may be obtained. By means of these numbers and the diagram at Fig. 18, the corresponding total deflection for each line may be measured. By means of the deflections so obtained the combined stiffnesses were computed for each phase of engagement, their total being the stiffness of the system at the instantaneous phase of engagement. On the basis of the data obtained, the diagram in Fig. 19 was constructed. This diagram shows how the stiffness of the system varies during the period of engagement for various face widths. In all these computations, the specific load—load per unit length of the gear—was the same (1 gramme per millimetre), which made it possible to compare the results obtained for helical and spur gears. From this diagram (Fig. 19) it can be seen that lengths (face widths) of the gears exist for which the stiffness of the system practically does not change during the engagement period.

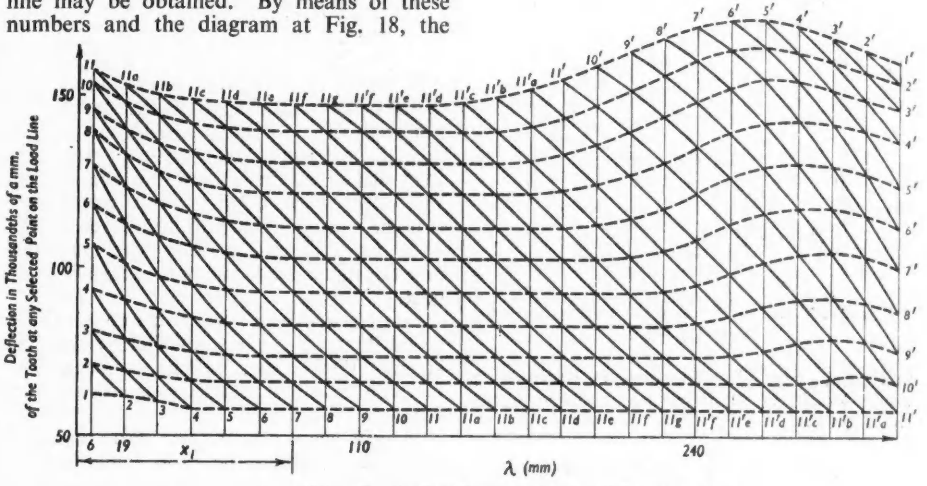


Fig. 18—Deflection along contact line when $\gamma=10$ deg., load distributed according to Table I depending on their length and position. Deflection curve 9–9 corresponds to the contact line 9 in Fig. 10 and deflection curve 9′–9′ to the line 9′

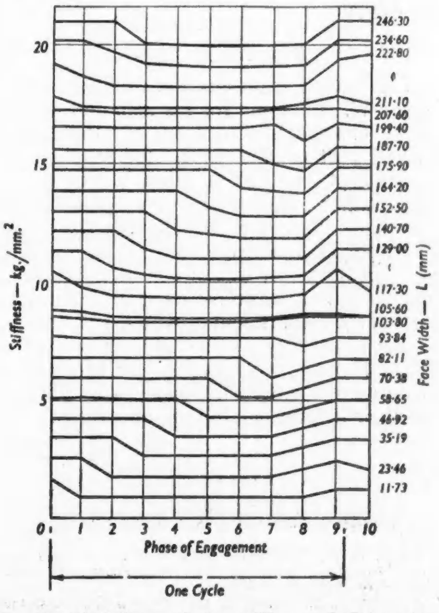


Fig. 19—Variations of the stiffness of the system during the engagement period for various gear lengths (=axial length of the contact line) when $\gamma=10$ deg. Abscissae denote phases of engagement, ordinates the stiffness of the system (left) and the gear lengths (right)

If, then, for each chosen length of the tooth the deflections of the system are computed, with the gear loaded with *L* grammes, where *L* denotes the face width of the gear in millimetres, it is possible to investigate what effect changes in the stiffness will have on the deflections of the system. Plotting deflection variations against the length of the gear, the curve shown in Fig. 20 was obtained. This curve has a number of singular points in which the function has its local minima. The abscissae of these points determine those lengths of the gears for which working conditions are most favourable. These are the very same lengths for which the stiffness of the system in Fig. 19 remains unaltered during the engagement period (e.g. when $L=207\cdot6$mm). The abscissae of these points correspond to such lengths of the gears for which the ratio between the length and the axial pitch is an integer.

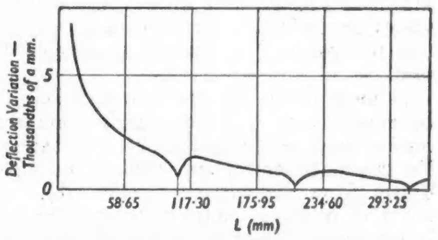


Fig. 20—Deflection variations plotted against gear lengths when the specific load=1g/mm and $\gamma=10$ deg.

Within the elastic range, the bending stresses and shear stresses in a gear tooth are proportional to the deflection of the tooth. In order to find the most convenient γ angle, deflection variation and the maximum deflection of the mating teeth were plotted against γ angles. Both functions are given in Figs. 21 and 22. The first curve has its minimum when the γ angle is 5 deg., and the second when it ≃10 deg. In both cases the specific load was the same for all angles γ. Deflection variation could be considerably reduced provided a suitable gear length was chosen, as shown above, so that to determine the best γ angle the maximum deflection should be used as a criterion. Fig. 22 shows that the optimum γ angle would be 10 deg., which corresponds to σ=27 deg.

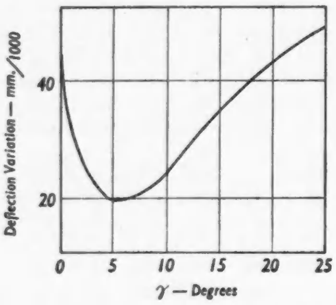


Fig. 21—Combined deflection variation plotted against γ angle

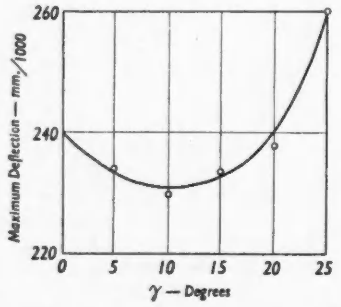


Fig. 22—Maximum combined deflections plotted against γ angle

RELIABILITY OF THE RESULTS OBTAINED

The forms of the various deflection curves experimentally obtained resemble one another. Their position, however relative to the abscissa axis, would differ for some lines, when measurements were repeated; to be able to tell which of the obtained curves was the most reliable, diagrams as shown in Fig. 18 were drawn and the best values determined by comparison. In every case the course of the curves could be easily seen.

In these results the errors are unlikely to be greater than ±3 per cent, so that the results may be considered as satisfactory. To this statement is appended an example drawn from the curve 9–9 (Fig. 18). In order to obtain a constant total deflection it was found necessary to add at each successive filling, in relation to the position of the pipe, 8, 9, 10, 10, 10, 10, 10, 9, 8 balls. Trials with 9, 10, 10, 10, 10, 10, 10, 10, 9, or 7, 8, 9, 10, 10, 10, 9, 8, 7 balls have proved unsatisfactory. According to this it could be concluded that the difference of 4 balls (which is the difference when 4×8 balls are added instead of 4×7) was the limit of the error. Expressed as a percentage the error would be $4\times1\cdot462/192\cdot63=0\cdot0303$, or 3·03 per cent.

During the experiments considerable scattering of the points was often observed, so that some experiments had to be repeated many times. The total number of readings exceeded 70,000. If some other materials more suitable than rubber could have been found, even with a greater Young's modulus, but more nearly homogeneous and with better elastic isotropic ability, all work could have been speeded up and a few thousand readings would have sufficed. Scattering might have been caused by variation in the weight of the balls and the pipes, by hysteresis or by slight impacts which occurred when the balls were inserted. As stated before, all measurements were carried out in the Hooke's law region. This means that there is a certain similarity between the behaviour of the rubber tooth and a steel tooth, so that the results obtained are probably applicable to the study of steel teeth. There is a difference between helical and straight teeth, which is taken into account by means of the form factor. There is no method by which the validity of this method could be checked, but it is to be hoped that strain gauge measurements will make it possible to grasp this difference more completely.

CONCLUSION

It was found experimentally that load distribution along the contact line of a mating pair of teeth is nearly uniform. Loading at the ends of the contact line is a little less than that in the middle. The difference between the maximum and the mean load in the worst case did not exceed 2·2 per cent. In technical literature[3, 4] it is stated that this relation is 50 per cent and even more.[12]

It was found that the above stated load distribution will change if the gears have not teeth of equal length, or have a relative axial displacement. In this case the maximum load occurs at the end of the contact line where the edge of the tooth comes into contact with the other tooth. Even in this case the difference between the maximum and the mean load does not exceed 6·3 per cent.

Short helical gears (where the contact ratio is less than 2) are less satisfactory than the spurs. These gears suffer a sudden load increase when a single pair comes into contact.

Helical gears are at their best, regarding static loads, when the ratio between axial length of the teeth and the axial pitch is an integer. Only in this case does the stiffness of the system of simultaneously engaged teeth remain constant throughout the period of engagement and the amount of variation in the specific load distribution will tend to zero.

The most favourable helix angle might be considered as that angle for which, under equal specific load, combined deflection is a minimum. This condition is fulfilled (for the tooth form used in these tests) when σ=27 deg.

ACKNOWLEDGMENT

The author expresses his thanks to Professor W. A. Tuplin for his help and advice, which enabled him to carry out the experimental part of this paper, for reading the manuscript, and making valuable suggestions. The author also wishes to acknowledge the late Professor V. Farmakovski and Professor D. J. Vitas, whose help in the final stage of the paper was of considerable value. Thanks have to be conveyed to the laboratory staff of the Department of Applied Mechanics in the University of Sheffield, as well as to the staff of the workshop of the Mechanical Institute of the Serbian Academy of Sciences for their help in making the apparatus.

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Prototype Tube Trains

A NEW type of underground train, which is intended as the standard for future replacements of London tube rolling stock, was recently shown to the Press by London Transport. Three of these seven-car prototype trains will shortly enter passenger service on the Piccadilly Line, and if they prove satisfactory, the design will be used for the re-equipment of the Piccadilly and Central Lines.

The three new trains have been manufactured, to the designs of Mr. A. W. Manser, the chief mechanical engineer of London Transport's railways, by the Metropolitan-Cammell Carriage and Wagon Company, Ltd., the Gloucester Railway Carriage and Wagon Company, Ltd., and the Birmingham Railway Carriage and Wagon Company, Ltd. While the individual builders have been allowed some scope in manufacturing details, the trains have similar overall dimensions, general layout and equipment.

The new cars are panelled in unpainted aluminium alloy and their design follows standards incorporated in the 1938 Tube Stock. The major changes in this new stock is in the use of rubber springing for the bogie bolster and axlebox suspension, the introduction of fluorescent lighting, and the panelling in aluminium alloy. Other changes include a better arrangement of transverse seats in the centre bay, an improved development of retractable shoegear, a modified electro-pneumatic brake system designed to facilitate maintenance and improve reliability, and a roller blind destination indicator above the centre cab doorway, illuminated by a fluorescent tube. Details first introduced on the latest District Line stock, such as trackless doors, mercury door interlocking equipment, and door fault indicator lights, which have proved their worth in service, have also been incorporated in the prototype tube trains. Opportunity has also been taken to try out two new patterns of motor-driven air compressors, both of which have been specially designed to fit in the very restricted space under a tube car.

To conform with the existing Piccadilly Line standard, each train consists of seven cars divided into four-car and three-car units, each unit being semi-permanently coupled. Each unit has a driving cab at both ends so that if necessary both can operate in passenger service, but full automatic coupling is provided only on the "inner" driving cars of a seven-car train which are to be known as "Uncoupling Driving Motor Cars" (U.D.M.s). The "Outer" driving cars of a seven-car train (D.M.s) are fitted with a simplified form of "Wedglock" coupler to provide mechanical coupling only for emergency purposes.

The design of the bogies closely follows that adopted on two advance prototypes which have already had some 100,000 miles in passenger service without any trouble being experienced or need for modification revealed. The system of springing uses rubber in combined shear and compression for both bolster and axlebox suspension and was developed in collaboration with Metalastik, Ltd. In it the large number of wearing parts associated with conventional steel springing are eliminated, and hydraulic shock absorbers are used to damp out vertical and lateral oscillations.

WORLD PETROLEUM CONGRESS.—We are informed that the Fifth World Petroleum Congress will be held in the Coliseum, New York City, in June, 1959. Some 200 papers will cover a number of key subjects and a main item will be a symposium on the exploratory use of atomic energy for new methods of processing oil and for creating new oil products.

Performance of Heat Exchangers

By EDWARD A. BRUGES, B.Sc., Ph.D.*

THE effectiveness of a heat exchanger is defined as the ratio of the heat actually taken up by the heated fluid to the maximum amount of heat which could be taken up from the heating fluid. In terms of the symbols of the accompanying diagram, Fig. 1, the effectiveness, ε, would be given by

$$\varepsilon=\frac{w_2c_{p2}(T_4-T_3)}{w_1c_{p1}(T_1-T_3)}$$

the value of T_2 not appearing in the expression. It is customary to assume that there is no loss of heat either from the heated fluid or from the heating fluid to the surroundings,

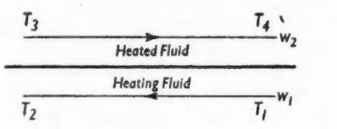


Fig. 1

i.e. $w_1c_{p1}(T_2-T_1)=w_2c_{p2}(T_4-T_3)$. In certain fields, for example, in the assessment of an exhaust heat exchanger of a gas turbine plant $w_1c_{p1}=w_2c_{p2}$ and the effectiveness or so-called thermal ratio is given by

$$\frac{T_4-T_3}{T_1-T_3}.$$

The writer contends that the effectiveness is an insufficient criterion for the assessment of heat exchanger performance and that the ratio of the available energy transfer would provide a proper thermodynamic criterion of performance. In the above instance the "energy transfer ratio" would be given by

$$\frac{w_2(b_4-b_3)}{w_1(b_1-b_2)},$$

where $b=h-T_0s$, the availability function. [h=enthalpy, s=entropy, and T_0 temperature of surroundings, deg. R.] By using this ratio instead of the thermal ratio account may be taken of a pressure drop in the fluids. Further, the effect of pressure drop can be related to temperature drop, where a temperature drop occurs either due to a heat loss to the surroundings or, in a contra-flow arrangement, see above, to the fact that $T_1>T_4$ and $T_2>T_3$.

Taking air as the medium on both sides of a contra-flow heat exchanger, the writer examined a number of possibilities.

(*a*) The effect of having the heated and heating air at different pressures.

(*b*) The effect of having a pressure drop on the heated and/or heating side, taking the heating air to be at a lower pressure than the heated air.

(*c*) The effect of a heat loss from either the heated or heating air without pressure losses.

Consider each in turn, taking $T_0=520$ deg. R.

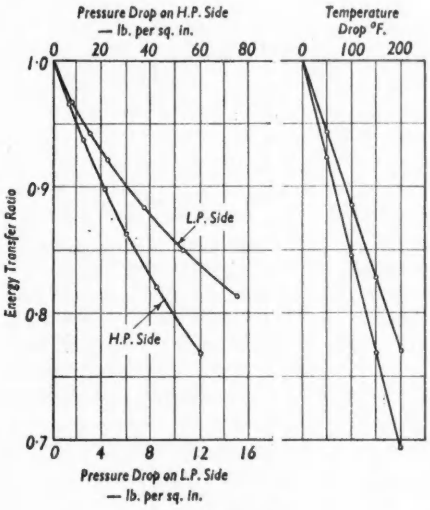
(*a*) It was assumed that the exchanger was 100 per cent effective, with $T_1=T_4=1500$ deg. R. and $T_2=T_3=600$ deg. R. Having the heated and heating air at different pressures makes no difference to the energy transfer ratio, since the change in the entropy of the heated air is equal and opposite to that of the heating air. Under these ideal conditions the energy transfer ratio will be unity.

(*b*) Assuming 100 per cent effectiveness with the same temperatures as in (*a*), the value of the energy transfer ratio was evaluated under the following conditions.

(i) Heated air at a constant pressure of 60 lb per square inch; exit pressure of heating air, 15 lb per square inch, with inlet pressure varied from 15 lb up to 30 lb per square inch.

(ii) Heating air at a constant pressure of 15 lb per square inch, exit pressure of heated air, 60 lb per square inch, with inlet pressure varied from 60 lb up to 120 lb per square inch.

The results of (i) and (ii) are shown in Fig. 2, where the energy transfer ratio is plotted to a base of pressure drop. It is emphasised that conditions represented in Fig. 2 refer to 100 per cent effectiveness. It is seen that for a given energy transfer ratio a larger drop in pressure can be suffered in the high pressure air than in the low pressure air. For the chosen conditions a pressure drop of 4·5 lb per square inch on the heating side is equivalent to a pressure drop of 16 lb per square inch on the heated side.



Figs. 2 and 3

(*c*) Assuming that the heating air is cooled from 1500 deg. to 600 deg. R., and that there is loss of heat from the heated air such that its temperature is raised from 600 deg. R. to some temperature below 1500 deg. R., the effectiveness and energy transfer ratios are each less than unity. The results are shown in Fig. 3, where the two ratios are plotted to basis of temperature drop, being the difference between 1500 deg. R. and the actual temperature attained. The same curves are obtained if it is assumed that there is a loss of heat from the heating air. It appears that the loss due to the pressure drops quoted above is roughly equivalent to a 50 deg. Fah. temperature drop.

The results may be combined together. For example: to find the energy transfer ratio with pressure drops of 3 lb and 12 lb per square inch on the low and high pressure sides, respectively, and with a 50 deg. Fah. drop (on the heated side), the energy transfer ratio is $0\cdot943\times0\cdot937\times0\cdot920=0\cdot813$, as compared with an effectiveness of 0·942.

The above and subsequent calculations were all based on the properties of air and gases given in Gas Tables,† that is on properties taking account of variable specific heat. Similar results could equally well have been obtained on the basis of constant specific heat. However, certain objections arise when constant specific heat is used instead of variable specific heat for cases when the fluids exchanging heat are different. Consider the following problem in which CO_2 gas is heated by air from 600 deg. to 1500 deg. R., with 100 per cent effectiveness (Fig. 4) (no pressure drops assumed).

Equating enthalpies, the ratio CO_2/air is 0·996, but the energy transfer ratio is 1·014, a figure which indicates violation of the Second Law of Thermodynamics. The impossibility of having heat transfer under the arrangement shown in Fig. 4 is not unknown, but perhaps not widely publicised. Difficulties which do not appear when constant specific heat is used appear when account is taken of variable specific or when tables of properties of gases are used. If a step by step analysis of the above case is made it is found that the variation of the specific heat of the two gases is such that a positive, however small, temperature difference cannot be maintained between the air and the CO_2. Under the above conditions 100 per cent effectiveness is impossible, although various compromises are possible within the above range of temperature, none of which lead to 100 per cent effectiveness nor consequently, to an energy transfer ratio of unity. The same may be found for any number of gases due to the specific heat varying in different ways for different gases.

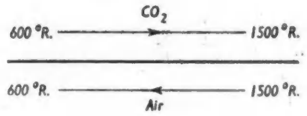


Fig. 4

In conclusion, the writer suggests that the energy transfer ratio, defined above, would serve as a better criterion of performance of heat exchangers than the effectiveness. It has been shown how pressure losses and heat losses may be related. Further, it has been shown that the assumption of constant specific heat may obscure certain real difficulties which arise when endeavouring to meet the conditions proposed in Fig. 4. In most problems the temperature difference between the fluids is so great that the possibility of violation of the Second Law of Thermodynamics does not arise. While the attainment of 100 per cent effectiveness may be desirable, though practically somewhat difficult, it may in fact be impossible.

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* Lecturer in Mechanical Engineering, University of Glasgow.

† Keenan and Kaye, John Wiley and Sons, Inc., New York.

Barges for Tame Valley Canal

IT is reported that more than 400 tons of material a week are being transported from one Birmingham firm to another on the Tame Valley Canal. This traffic consists of goods sent by Forgings and Presswork, Ltd., to Hardy Spicer, Ltd., an associate company whose factory is 4 miles away. The three barges used were made by William Harris, of Netherton, and are 54ft long, with a width of 7ft and a draught of 2ft 9in. Guide rails centralise loading, and each vessel can carry 20 to 25 tons. The tug, produced by E. C. Jones, of Brentford, is powered by a 24 h.p. Lister "Freedom FRM.3" diesel engine, and makes four two-hour round trips a day. The tug and barges are designed to enter each of the two locks as a unit.

The premises of the two firms were formerly adjacent to one another, and bulk transport was then no problem. When Hardy Spicer, Ltd., moved to a new factory at the beginning of the year, however, the problem arose in earnest. Investigation suggested that a barge service would be the most economical solution, and events appear to have borne this out. The saving on the cost of road transport is estimated at 50 per cent.

LETTERS AND LITERATURE

Letters to the Editor

We do not hold ourselves responsible for the opinions of our correspondents)

COMPRESSION TESTING MACHINES FOR CONCRETE

SIR,—In his letter in your issue of July 5, Dr. Plowman comments on the use of averages of three concrete cube test results in my article to which he refers. This is a little surprising, as in no case have I quoted an average of three test results, and only in the case of Series 5 did I quote averages of four. Admittedly, in Series 1 and 2, three cubes from each batch of concrete were tested on each machine, but as the investigation was not concerned with any variation between batches, the experiment provided almost as much information as if all the cubes in Series 1 or Series 2 had been made in one batch. In addition, apart from the problems that would be involved in producing 270 4in cubes or 144 6in cubes from one batch, the variation between cubes so made would inevitably be greater than that obtained by using a larger number of smaller batches. With regard to the variation of cube strengths within batches of concrete, the results in Series 1 showed a standard deviation of 250 lb per square inch, so that the average of thirty results would have a standard error of 45 lb per square inch. The results in Series 2 showed a standard deviation of 200 lb per square inch, corresponding to a standard error of 40 lb per square inch in the average of twenty-four results. Standard deviations of the same order were obtained in the remaining series of tests.

Referring to Dr. Plowman's final point, the graduations on the various machines were as follows: machines 1 and 2, 1000 lb (0·45 ton) divisions up to 225,000 lb and 2000 lb (0·9 ton) divisions up to 450,000 lb; No. 3, 0·5 ton divisions; No. 4, 0·5 ton divisions up to 80 tons and 1 ton divisions up to 200 tons; Nos. 5 and 6, 0·0001in, corresponding to 0·7 ton and 0·4 ton divisions, respectively; Nos. 7 and 8, 0·1 ton divisions with verniers reading to 0·01 ton; No. 9, 1 ton divisions. The various gauges were read to one-fifth of a division, or, in some cases, to one-tenth of a division and, while it is conceded that the final digit may be in error, I suggest that the reading error would not be greater than one-fifth of a division. The worst case arises with machine No. 9, where reading errors of up to 0·2 ton might arise, and this is only 0·4 per cent of the average value recorded in Series 1. Moreover, the averaging of a number of results reduces the effect of such errors, which in any case are included in the standard deviation quoted above and I do not consider they have any appreciable importance in the present investigation.

As a guide to the desirable graduations on a testing machine, I suggest that since a Grade A machine is required to be accurate to within ½ per cent down to one-fifth of the full-scale reading, i.e. the strictest requirement is an error not exceeding one-thousandth of the full-scale reading, this quantity should be one-half of a division. These conditions would then correspond to the weights and measures requirement for weighing machines, namely, that the error should not exceed one-half of a scale division. It follows from this that a Grade A machine should have 500 graduations on any scale. Similarly, a Grade B machine would require 167 graduations.

Mr. Carter, in his letter, also published in your issue of July 5, raises the question of which method of testing concrete in compression gives the truest indication of the strength of the concrete. This question introduces numerous problems other than those discussed in my article, such as whether cubes or cylinders are better, the two types of specimen giving appreciably different results. Some of these problems have been discussed elsewhere.[*] The important point is that the crushing test is essentially used as a general indication of quality and not as a direct measure of the stresses which the concrete would be capable of withstanding in a structure, where the conditions are very different from those in the test. This being so, the best method of test is that which introduces the least variation into the observed results. Since the variation of results is compounded, according to simple laws, from the variation of the concrete and the variations arising from the testing technique, it follows that the test which gives the least variable results is the one which introduces the least variations and it is on this basis that the conclusions in my article were developed.

With regard to Mr. Carter's fear that with existing machines the weaker cubes may be tested with an essentially "free" platen, whereas with the stronger cubes the platen will approach the "fixed" condition, I agree that there is scope for more research. Much probably depends on the contact areas of the seatings, the surface finish and the lubricant used.

P. J. F. WRIGHT

Road Research Laboratory,
Harmondsworth.
August 7, 1957.

SPEED FACTORS FOR GEARS

SIR,—I was interested to read the letter (page 160) from Mr. M. Boomsma on this subject.

It is not immediately obvious why there should be any connection between an index −0·2 applied to the rotational speed of a gear as a measure of the variation in permissible nominal loading with speed, and an index 0·8 (even if written 1—0·2) applied to the diameter of a gear as a measure of the variation in permissible nominal loading between geometrically similar gears of different sizes running at a common rotational speed. Any superficial numerical similarity between indices of entirely different quantities in a formula derived empirically from service results on widely different gears with many uncontrolled variables is surely just a matter of chance.

W. A. TUPLIN

Sheffield, August 10.

Book Reviews

Practical Microscopical Metallography. Fourth edition. By R. H. GREAVES and H. WRIGHTON. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 70s.

THE third edition of this standard work appeared in 1939 and had been reprinted five times by 1950. All metallurgists should be familiar with it and will welcome this new edition as heartily as they did the earlier ones. As the title would indicate, its primary purpose is to describe the methods most suitable for preparing metals and alloys for examination and photographing by means of the microscope. In the new edition, the chapter dealing with the microscope and methods of microscopical examination has been expanded and there are additions to the practical notes on particular materials. Reference is made to the latest developments of objectives and methods of illumination used in optical microscopy, and among new illustrations are photomicrographs taken with the new equipment described. The principles of examination by polarised light, by phase contrast and by light profile methods are briefly described and illustrated. Separate chapters containing some new photomicrographs are now devoted to alloys of aluminium, magnesium and nickel. The seventy-eight plates include 356 photomicrographs and macrographs, suitably annotated, usually of the highest quality, and constituting an indispensable reference album for the metallurgist. The examples (Plates 8, 10, 14 and 16) of the variation in definition of the same microstructure under different conditions are most instructive. Defects causing difficulties in manufacture or leading to premature failure in service—e.g. ghosts, slag inclusions, sulphide films, cracks, rokes, &c., in steel—are excellently described and illustrated.

The book has been written to supply the needs of metallurgical students, engineering students who study metallography as part of their engineering course, practising engineers and other metal users. Therefore the authors have added "a concise account of the results of metallographic researches and other investigations, in so far as they afford an interpretation of the structures and associated properties of commercial materials." This excellent intention, however, is attended by a fundamental difficulty, which the authors have not succeeded in overcoming. Metallography is a highly complex subject, about which it is not easy to be concise. One has to resist the temptation to simplify explanation by leaving out all the difficult parts. It is also difficult to avoid making general statements, which are mainly correct, but should strictly be hedged about with provisos; and, without those qualifications, can be misleading. A few examples may be given.

On page 89 the authors correctly describe pearlite as composed of alternate lamellæ of ferrite and cementite, and say it was so called because of the iridescent colours, resembling those of mother-of-pearl, shown on oblique illumination. This, incidentally, is because the cementite is much harder than the ferrite, so that, on polishing, it is left in slight relief above the ferrite. The surface thus exhibits a series of minute ridges and valleys, which act much as a diffraction grating, giving rise to the colour effect in question. On page 90 the authors say that the effect of heating pearlite for a long time at 700 deg. Cent. is to produce a structure consisting of coalesced particles of carbide in a ground mass of ferrite, as is perfectly true. But to describe this constituent—which is merely a decomposition product of pearlite—as " granular pearlite," when the characteristic lamellar structure has entirely disappeared, and the colour effect in question is no longer obtained, is hardly satisfactory. On page 92, in discussing how one can determine the strength and ductility of normalised or annealed carbon steels by calculation from the proportions of the constituents in the microstructure, the authors refer to " normal lamellar pearlite," with 55 tons per square inch tensile strength and 15 per cent elongation ; and to " laminated pearlite " with 35 tons per square inch tensile strength and 5 per cent elongation. Since " lamellar " and " laminated " are synonymous terms, the authors might have described how these two varieties of pearlite differ, and also explained the remarkable variation in mechanical quality. In reality, are not the two identical, with a tensile strength of some 55 tons per square inch and 10 per cent elongation ? The authors say (page 134) that piping in steel ingots always appears except in a " wild " cast (i.e. one in which blowholes are formed throughout the ingot). This is true, but hardly conveys a correct impression. In practice, steel made in " wild " casts, i.e. rimming steel, is used—on a scale far greater than piping steel—for sheets, strips, tinplates and so forth. Again, careful control is necessary to ensure the correct degree of liberation of carbon monoxide gas in the semi-solid mass—and consequent increase in the nominal volume of the solidified steel—as just to make up for the normal solidification shrinkage. One thus avoids the production of the central pipe commonly found in killed steel ingots and enables a much greater proportion of the ingot to be utilised.

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[*] Jones, R., and P. J. F. Wright, "Some Problems Involved in Destructive and Non-destructive Testing of Concrete," *Proceedings of a Symposium on Mix Design and Quality Control of Concrete*, London, 1955 (Cement and Concrete Association).

On page 144, where the authors say that the carbon content of the eutectic, ledeburite, in cast iron is reduced by " rather more than 0·3 per cent " for each 1 per cent of silicon present, they might have said that the same also applies for phosphorus, the " equivalent carbon content " being thus the actual carbon content plus one-third of the silicon and phosphorus contents. The authors say that hyper-eutectic cast iron is likely to contain coarse graphite flakes which separate " at the moment of solidification." With such irons, graphite separates *before* solidification, appearing as a layer on the surface of the metal in the ladle after tapping, and known as " kish " by the foundryman. What *is* deposited directly from the melt at the moment of solidification of grey cast iron is the stable austenite-graphite eutectic, the graphite being in coarse flakes of lamellar form. Alternatively, the metastable austenite-cementite eutectic may be deposited—at a temperature lower than that at which the stable eutectic is produced—the cementite decomposing, at some temperature below that of complete solidification, to give rise to " undercooled " graphite in a much more finely divided form.

On page 166 the factors showing the " zinc equivalence " of the various alloying elements used in special brasses are given, and the structures of various alloys are determined by calculation on these bases. It is, however, only when the proportion of the additional element does not exceed some 2 per cent that the structure of the slowly-cooled alloy can be determined with reasonable accuracy in this way ; and the method cannot safely be extended to cover alloys containing 3, 4 and even 5 per cent of aluminium, examples of which are quoted.

We could continue, but it would be both tedious and unprofitable. These criticisms, however, should not be regarded as detracting seriously from the value of the book, for its primary purpose is admirably fulfilled, and there are few metallurgical laboratories which would not profit by obtaining a copy. For the practising metallurgist, who can exercise the necessary discrimination, it will often provide a useful conspectus of a field other than his own. For the student, it will be better to use it in conjunction with a standard textbook on the particular subject.

Steelplant Refractories : Testing, Research and Development. Second edition. By J. H. CHESTERS. The United Steel Companies, Ltd., 17, Westbourne Road, Sheffield, 10. Price 80s.

ANY textbook pre-eminent in its own field of study, such as *Steelplant Refractories*, by J. H. Chesters, should not be allowed to pass without revision for more than ten years. The new edition incorporates a description of developments in the last decade and follows the same plan as its predecessors, dealing with the methods of testing, the various types of refractories, and their role in steel-making processes. The first half of the book is, in fact, useful as a textbook on the commonly used bulk refractories without specific reference to steel-making.

The chapter on the basic open-hearth furnace is expanded to include an examination of some of the effects on refractory performance of furnace design, type of fuel and metallurgical load. Additional data on the effect of refractory quality on roof life with special reference to super duty silica bricks, has been added to this chapter. The book shows that, despite the new work, the problems we had in 1946 are, in the main, still with us, and many of the suggestions for improvement are the same as those given then. The book, especially in the chapter on the acid open-hearth furnace, reveals that the steel industry is changing its attitude and is aiming more and more for greater rates of production rather than long life from the furnaces.

The theoretical sections are not quite so satisfactory ; for example, the treatment of phase diagrams is rather sketchy, relying too often on a reference to the extensive and well-classified bibliography. In addition, the relationship of the fundamental atomic structure of the materials to their properties is not well brought out. This very minor criticism, however, does not detract from the value of this book to the refractory manufacturer and user for whom it was designed. They will find the book in every way as useful as the earlier edition, written in a style that is both readable and concise with new illustrations to supplement the old, and the same useful information in twenty-odd appendices.

Solar Radiation in Air Conditioning. By IVOR S. GROUNDWATER. Crosby, Lockwood and Son, Ltd., 26, Old Brompton Road, London, S.W.7. Price 25s.

A FEATURE of many buildings designed in the modern idiom is that they are lighter in weight than the conventional masonry construction, and incorporate a higher proportion of window area. These two factors, especially the latter, emphasise the importance of radiation in the calculation of indoor temperature. Solar radiation is particularly important with this kind of construction in climates where air conditioning is normally required. It has created thermal problems which must be understood and solved if such buildings are to be made comfortable under all circumstances in an economic manner. The consulting engineer, architect, and air conditioning engineer for whom, it is claimed, this book is primarily intended, will find very little in it that is not already widely known to help them tackle the difficult problem of solar radiation in air conditioning. Such factors as sol-air temperature, amplitude decrement and time lag, all important in the determination of cooling loads, are mentioned very briefly without definition or discussion. A design for air conditioning is essentially a problem in variable heat flow, but this is not discussed. The first part of the book deals with solar design data summarised from several sources, principally American. Data that is more up to date could have been included and presented with a rather more critical examination than has been attempted. Four methods that have been adopted commercially for calculating the sun load are described and used to estimate the heat gain for a particular installation. The results are compared with the installed refrigerating effect but in spite of the modifications, based on field experience, that are suggested for improving the agreement it would be unwise to form a judgment about the comparative accuracy of the various methods from an analysis of a single installation. No method of calculation, however refined, can be satisfactory unless it employs reliable basic data. In this connection the author rightly points out that more practical data on solar absorbtivity is desirable.

The Diesel Locomotive. By R. L. ASTON, A.M.I.Mech.E., A.M.I.Prod.E. Thames and Hudson, Ltd., 30, Bloomsbury Street, London, W.1. Price 12s. 6d.

THIS is essentially a practical book which will be of interest to and provide a useful reference work for diesel locomotive footplate staff and those concerned with maintenance in running sheds. It deals first with the basic principles of the diesel locomotive and engine construction and working principles. Individual sections then discuss in a clear, concise way fuel and fuel injection systems ; methods of engine starting and speed control, transmission systems ; auxiliary equipment and safety measures. The book concludes with chapters on maintenance planning and operating troubles, fault tracing and adjustments. Although most manufacturers in the diesel locomotive industry provide excellent running and maintenance manuals, this book provides the broader picture which will give those for whom it is intended a fuller appreciation of the subject.

Books Received

Merchant Ships : World Built. Vol. V, 1957. Adlard Coles, Ltd., 7, Brunswick Place, Southampton. Price 30s.

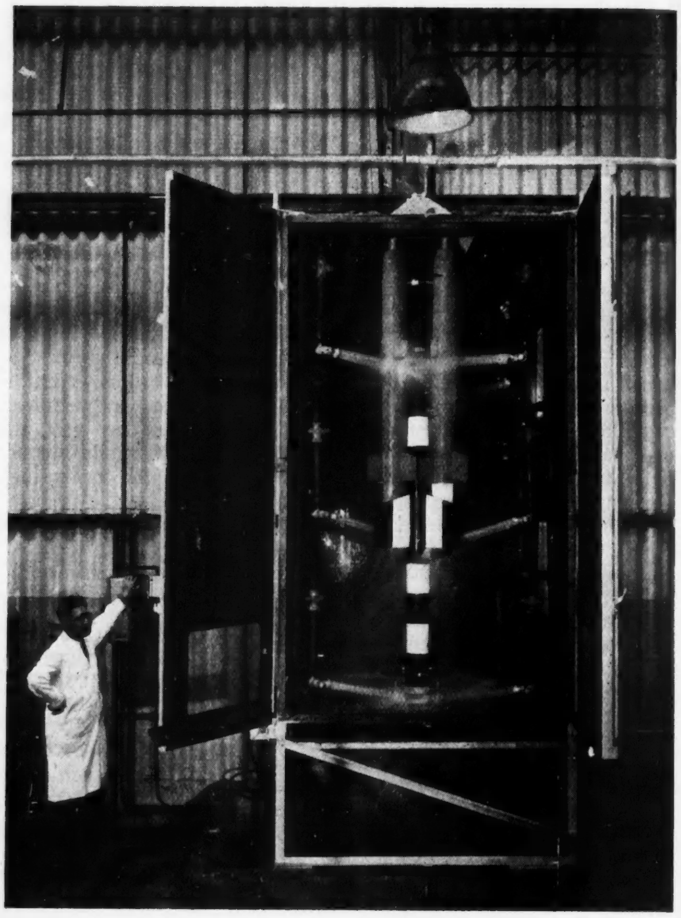
Industrial Electronics Circuits. By R. Kretzmann. Cleaver-Hume Press, Ltd., 31, Wright's Lane, Kensington, London, W.8. Price 35s.

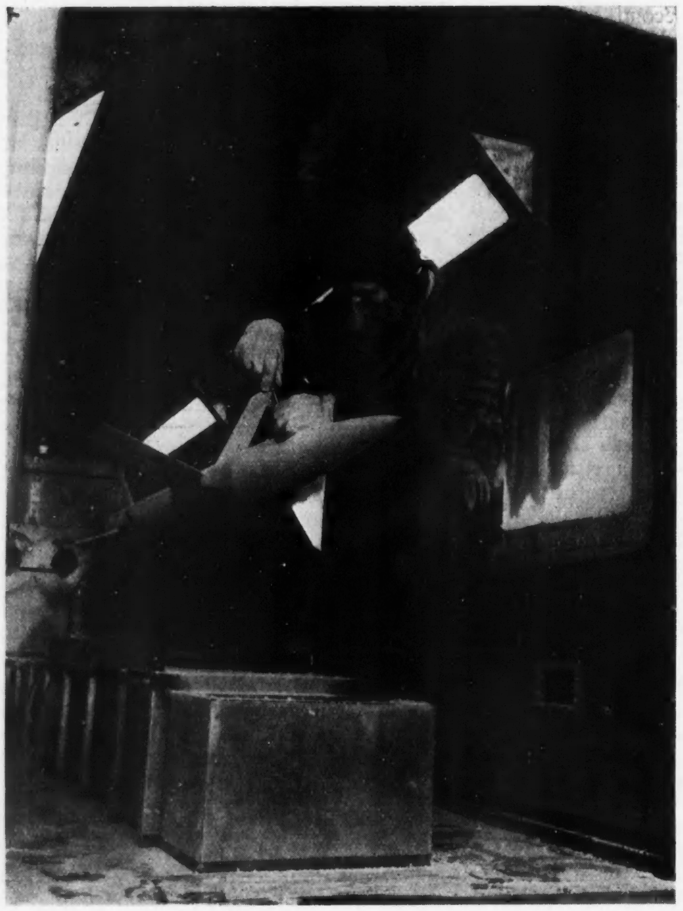
Principles of Engineering Heat Transfer. By Warren H. Giedt. D. Van Nostrand Company, Inc. 257, Fourth Avenue, New York, 10, New York, Price 48s.

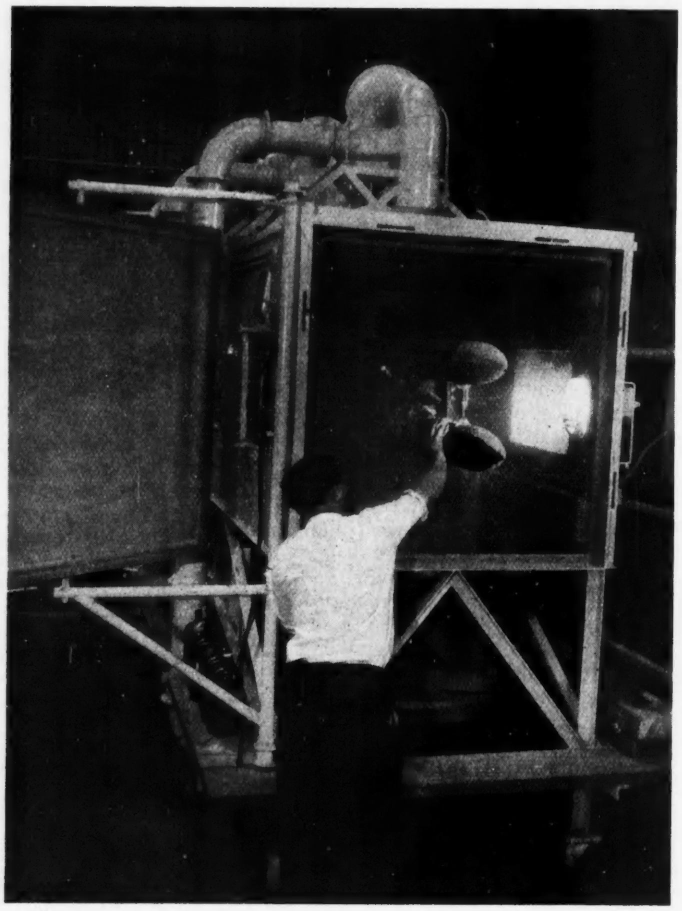
Principles of Engineering Inspection. By Geoffrey K. King and C. T. Butler. Cleaver-Hume Press, Ltd., 31, Wright's Lane, Kensington, London, W.8. Price 25s.

Aimed Fighter Missile

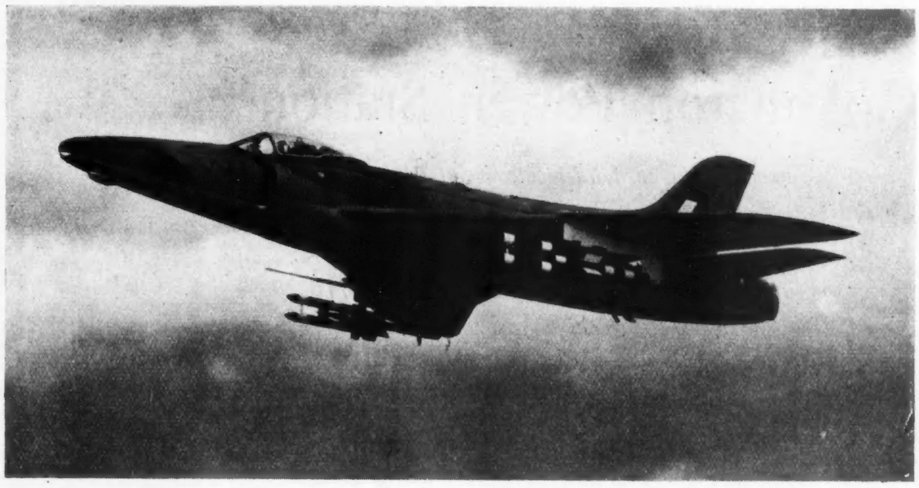
The unusual nature of the first British guided missile to become operational has recently been made public. The control loop of the Fairey "Fireflash" is closed by the pilot of the fighter aircraft from which it is discharged : the beam on which the missile rides is projected straight ahead of the aircraft, and "deflection" to minimise manœuvre is applied by the gyro gunsight. The aircraft installation estimates the range of the target before signalling "permission to fire" to the pilot, and while details of visual attack methods only have been released, it may be that target heading can also be presented to the pilot by radar. The missile fuse is active and capable of selecting the optimum instant for detonation, whether or not within lethal range. The weapons system is regarded as compatible with a large number of transonic fighters, presumably requiring auto-stabilisation, as in the "Meteor," or exceptionally fine handling qualities, for use against bombers of "Canberra" or "V" classes. It is thus clear that, while the weapons system is regarded largely as of training value to the Royal Air Force, it was actually conceived as an operational weapon extending the range of the armament of conventional fighters, and is an excellent example of an early guided missile rather than a rudimentary forerunner of highly automatic systems. This being so, the weapon was intended to have a high degree of immunity to climate, be resistant to carriage and prolonged storage, and be maintained and operated by easily trained service personnel. It is now in production at the Stockport factory of the Fairey Aviation Company, Ltd. The illustrations on this page show three tests simulating adverse environments. That above shows a missile in the Fairey cold chamber for subjection to arctic winter conditions, under which it can quickly become covered with ice : this is, of course, particularly prejudicial to the batteries. In the second, rain at 100 in per hour is represented by twelve water sprays, directed at exposed electrical components. The lowest illustration shows a round after an hour in a simulated dust and sand storm : the boost ignition and separation circuits are being checked. The pictures opposite show three phases of aircraft compatibility trials : in the first a Supermarine "Swift" is seen carrying the weapon : the elongated nose for the guidance equipment is conspicuous. The second shows a pair of rounds being prepared for ground firing to investigate the effect of rocket blast on the airframe : the wing is that of a "Swift," an early version without the notched leading edge, but the aircraft has not been seen to carry more than two rounds. In the last picture a missile is being jettisoned in the airstream of a blower tunnel at Boscombe Down : the net which will catch it is seen in the foreground, below the recording cine-camera.

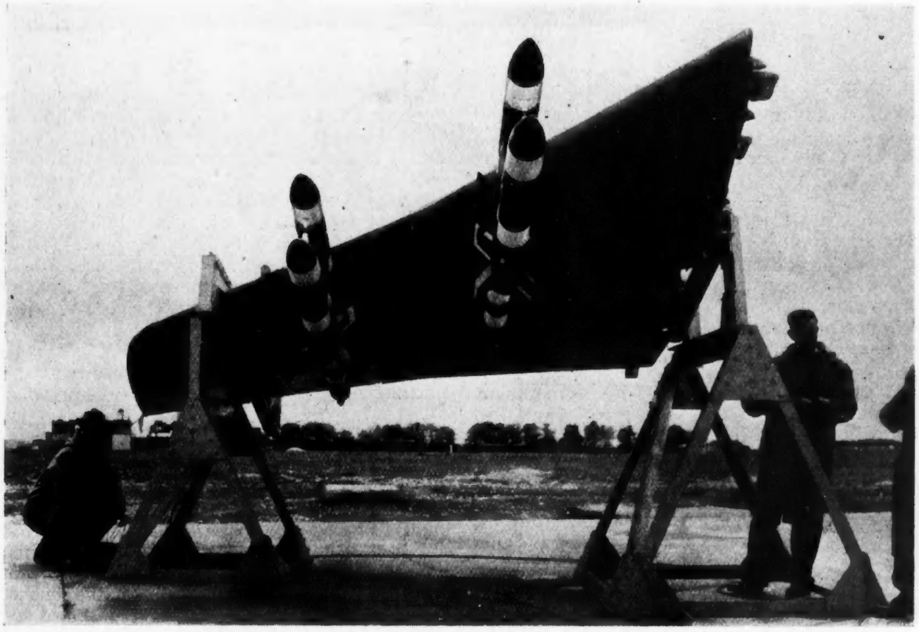




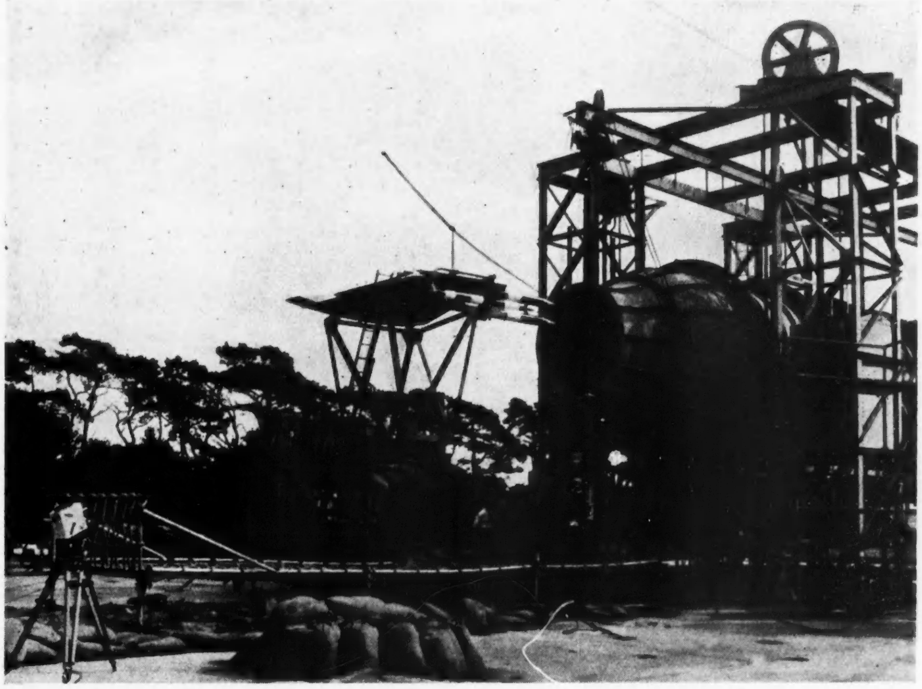


The "Fireflash" is a coasting missile accelerated to over Mach 2 by two solid rocket motors prominent in the pictures. The missile proper is 89in long and 28in in wing span, the overall length being 112in. The motors have a cordite charge with a star-shaped central hollow, and are sealed by rubber obturators until electrically ignited. The nozzles emerge in front of the tail fairing and are directed to spin the missile for stability. Shallow saddles and locating pins hold the motors on the round, the electrical circuits passing through pin and socket connections immediately forward of the thrust pegs. The motors are held together by the two separation units each side of the nose of the round, and held apart by an adjustable spacer between their noses: the weight of the missile on the launcher is taken through the upper rocket at a point at the front of the nozzle opening. When each of the rockets is all burnt, a pressure switch in the nose initiates separation: a cartridge in each of the separation units is fired, shearing the pin that holds the motors together and forcing them apart by a plunger-in-cylinder action. It is interesting to note that one of the fairings in front of the separation units carries three conductors between the motors.



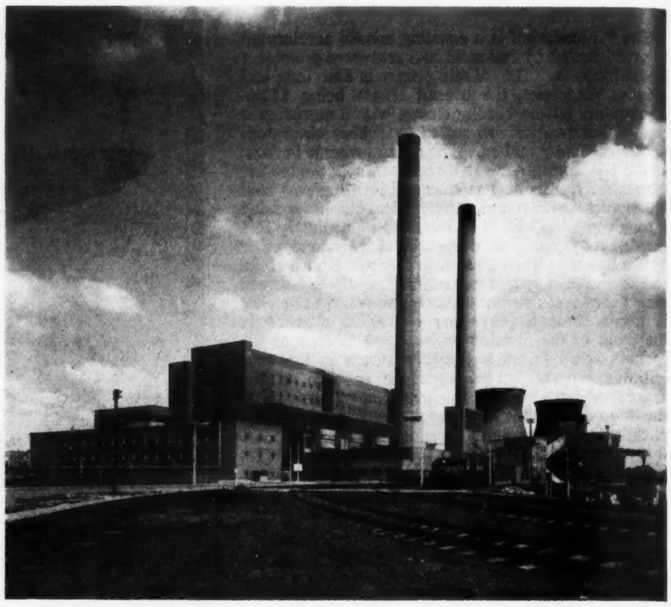


More than fifty test launchings of various configurations were involved in development of the separation mechanism. The weapon itself has a body of 5½in diameter, the ogive nose housing the fuse, the next section the warhead or telemetry transmitter, and the rear the guidance and control services. The main body consists of an extruded magnesium-zirconium alloy tube with the wing root buttresses forged into it. When on the carrier, warm air from the engine is distributed along the power and control bays inside the hollow rails carrying the components. The dart flies always in the same roll attitude as when launched; its roll gyro and one directing the polarisation of the guidance beam are uncaged simultaneously. When launched, the missile runs on a battery power pack and a reservoir of compressed air. During the acceleration phase the controls are locked: the longitudinal stability is very great with the motors attached, and the yaw and pitch rate gyros do not develop large displacements. All the gyros are air driven, and a weight-saving detail is the use of the nozzle as the locking detent for the roll gyro: the gyros coast after launching. When separation has occurred the warhead is armed, and the controls are unlocked: the missile is flown straight ahead, roll stabilised, except as commanded by the guidance system seeking the beam between fighter and target. Displacement in roll is read off a potentiometer; rate of yaw and pitch signals are generated by magnetic inserts in the gyros and coils on the case. The frequency of this latter signal is used to control the supply of filtered air from the carrier and avoid over-speeding. Each of the control surfaces is driven by a pair of single-acting pneumatic rams, controlled by a single electrical relay valve, with potentiometer feed-back of the control attitudes. Each surface is attached to a drive shaft carrying the two control cranks and journalled in ball bearings. The guidance aerial is actually behind the control surfaces, an advantage of a coasting vehicle, and the 3000 lb per square inch air storage bottle is at the opposite end of the main body, immediately behind the warhead. Guidance is achieved by translating error signals, by knowledge of time of flight, into required accelerations along the two transverse axes of the vehicle, and applying yaw or pitch to derive the required acceleration from the lateral accelerometers. These consist of bobweights situated to the rear of torsion bars, and pick-off is again by potentiometers. The entire rear body can be separated from the rest of the round and checked on the operational airfield test set: this supplies electricity at low tension and compressed air both for control actuation and for cooling the electronics during prolonged running. Various angles of roll and rates of turn can be imposed by the test set: a separate installation tests the active fuse. Testing of the warhead is done using ohm-meters driven by photo-electric cells. The telemetry transmitter which can replace the warhead of this training weapon connects by four twelve-point junction boxes at the front bulkhead of the main body, and has aerials consisting of spanwise slots near the trailing edge of two of the wind roots, i.e. back on the main body. An indication of the great weight of warhead needed with this guidance system is that the practice nose cap used in front of the, presumably lighter, telemetry head is filled with lead and weighs of the order of 30 lb.



Goldington Power Station

Major Simon Whitbread, Lord Lieutenant of Bedfordshire, is opening Goldington power station to-day, Friday, August 16. The station supplies the 132kV national grid. The present capacity is 150MW, five of the six 30MW sets having been installed (it is planned to commission the final unit in January, 1958). Steam conditions at the stop valve are 625 lb per square inch and 865 deg. Fah. Particular attention has been paid to appearance, and the architectural design of the station has been recognised by the Royal Academy.



RECOGNISING the need for an additional generating station at the end of the last war, the Bedford Corporation joined the Central Electricity Board in searching for a suitable site. Vesting Day for the Central (then British) Electricity Authority came and went while the search was in progress, and responsibility for the project passed to the Eastern Division of the Authority. The site at Goldington was selected toward the end of 1948. Preliminary work began in 1951, and the first of the 30MW sets was commissioned, together with boiler and auxiliary plant, in June, 1955. The second generator was in service three months later,* the third and fourth in 1956, and the fifth last May. The sixth and final unit is due to be working in January, 1958. The station is being formally opened to-day, Friday, August 16, by Major Simon Whitbread, Lord Lieutenant of Bedfordshire.

The architectural design has formed the subject of a Royal Academy exhibit, especial care taken to produce a harmonious composition having been notably successful. Mr. W. N. C. Clinch, Controller of the Eastern Division, has directed the design and construction of the station. The main consulting engineers are Messrs. Merz and McLellan, with whom Sir Alexander Gibb and Partners are associated as civil consulting engineers.

SITE AND BUILDINGS

The site at Goldington was chosen for a number of reasons, one being the good load-carrying capacity conferred by gravel close to the surface. The nearness of the River Ouse and the Bedford–Cambridge branch of British Railways were additional factors that were considered.

The foundations were laid by driving reinforced concrete piles into the sub-surface gravel and forming a reinforced concrete "raft" on top of the piles. About 5000 piles were driven altogether. The steel frame of the station is clad with rustic brick. The administration block, which is insulated against vibration from the station, is a steel frame clad with brick and pre-cast concrete slabs. The reinforced concrete of the chimneys and cooling towers is of a tinted variety to blend with the brickwork of the station.

The chimneys are 325ft high and have an internal diameter of 18ft at the top. The boiler-house is 237ft long overall, and has a width of 69ft; the roof level is 212·5ft O.D. The turbine house is 396ft by 92ft, with electrical annexe 368ft by 22ft, the levels are 82·5ft O.D. ground, 108·5ft O.D. operating floor, 134·5ft O.D. crane rail, and 152ft O.D. roof. The administration, control and welfare building also houses the stores, at ground level: the building has dimensions 260ft by 51ft, and the roof level is 123ft O.D.; there are three floors. The cooling water pump house is 100ft by 44ft, and the levels are 58ft O.D. pump suction, 82·5ft O.D. operating floor, and 111·5ft O.D. roof. The mechanical and electrical workshops are each 73ft square.

HANDLING AND BOILER PLANT

Slack coal delivered by rail or road is handled by plant designed for the purpose. There are two tipplers, each able to unload 250 tons per hour from railway wagons. Coal is conveyed by twin belts and bucket elevators from the tipplers to the bunkers. Unlubricated nylon bearings are used with success on the bucket elevators. One 550-ton bunker is installed for each boiler. Alternatively, the coal may go from the tipplers to the store, which can hold 88,000 tons. A dragline scraper, of capacity 125 tons per hour, reclaims coal from stock and feeds it to conveyors serving the bunkers. Weighers and automatic samplers are fitted at appropriate points in the system and magnetic separators are also installed.

Coal passes under gravity from the bunker of each boiler to the pulverising mills, four of which are provided for each boiler. The main pulverisers (three per boiler) can each grind more than 9 tons per hour, a small mill (with a capacity of 2½ tons per hour) being provided for lighting up.

The boilers have twelve burners apiece. The burners are placed in banks of three at each corner of the boiler, and are fed by fuel fans. The flames are directed at a tangent to a circle the centre of which is at the intersection of the diagonals of the furnace. Steam temperature is controlled automatically by varying the angles of the burners. Combustion air is taken from the top of the boiler-house by two forced-draught fans, and is passed through a regenerative heater. The heated air then goes through the pulverisers to the combustion chamber, where the supply is augmented by air from inlets close to the burners. The gases from the combustion chamber pass through an economiser, and through the air heater already mentioned, after which mechanical extractors and electrostatic precipitators remove entrained particles. The cleaned effluent is passed to the chimney by induced-draught fans situated out-of-doors.

Six oil burners are used for lighting the boiler. Ignition is electrical. These oil burners also come into action (automatically) when the coal flame shows signs of instability. Fuel and air

The design of the 30MW two-cylinder, double-flow turbine was modified after the first two sets had been installed. The newer versions are nearer the camera in this view of the turbine room supplies to the boiler furnace are automatically co-ordinated in relation to the steam pressure at the superheater outlet. The self-draining superheater has high- and low-temperature sections in the path of the gas, and a single flow of steam across the unit. Deposits on the heating surfaces of the boiler are removed by fully automatic, retractable, sequentially-operated soot blowers. Ash handling plant deals with accumulations in the furnace and in the hoppers of the flue gas cleaning plant. Ash is sluiced from the water-filled furnace hoppers by high-pressure jets, and goes to a pit behind the station. A grab transfers the ash from the pit to lorries. Dust from the flue gas cleaner is moved pneumatically to a bunker behind the boiler-house, and discharged from the bunker into lorries underneath it. Special equipment moistens the dust to prevent nuisance.

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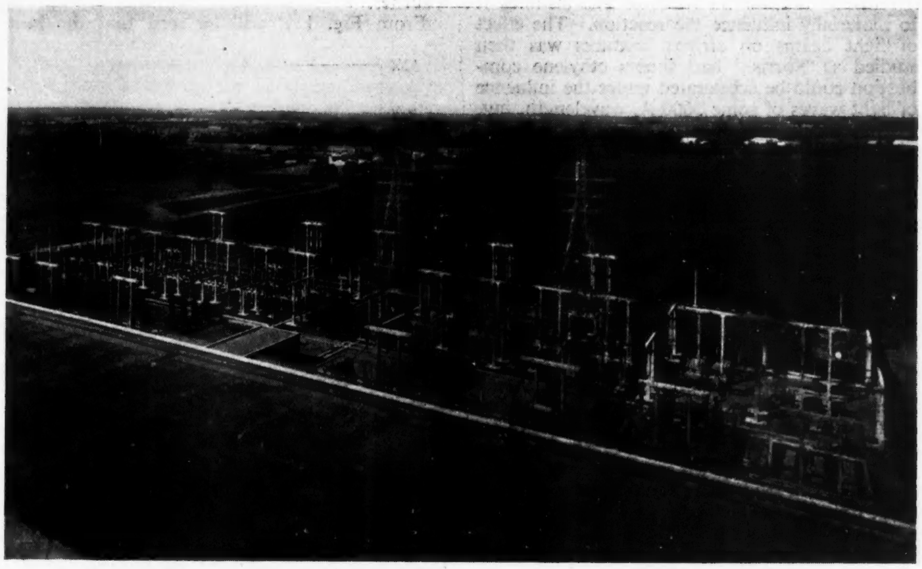
* THE ENGINEER, January 6, 1956.

An injection pump feeds conditioning chemicals directly to the boiler drum, and injection can also be effected at the inlet to the economiser. Raw water treatment is on principles that received their first consideration in this country in connection with Goldington power station, although they have since been applied elsewhere. The ion exchange plant that is used has been so satisfactory as to reduce the conventional evaporative equipment to the status of a stand-by. The water produced is sufficiently pure to be fed directly to the boilers, and it is estimated that the effect of the treatment on local water is equivalent to triple distillation. The plant is in two sections, each able to supply 5000 gallons of softened or completely treated water per hour.



The main 132kV switchgear is of the air blast type, with a rupturing capacity of 2500MVA, 11·8/132kV transformers connect the generators to the national grid. The transformers and switchgear are situated in a compound, as illustrated above : the compound is in front of the turbine house

Feed water is delivered to the boilers by motor-driven pumps at operating floor level. Two 100 per cent duty pumps are installed for each boiler turbine unit.

The boiler efficiency is 85 to 88 per cent. Stop valve steam conditions are 625 lb per square inch and 865 deg. Fah.

TURBO-ALTERNATORS

Each set is rated at 30MW, 37·5MVA, with a power factor of 0·8. The turbines are two-cylinder machines of the combined impulse-reaction type, with double-flow l.p. cylinder exhausting to twin condensers. The designed steam supply conditions are 600 lb per square inch and 850 deg. Fah. (superheated). Steam is bled from four points for feed heating in four stages to a final temperature of 340 deg. Fah at the maximum load of 30MW. The turbines for sets 3, 4, 5 and 6 are modified in relation to the first two installed, the h.p. cylinder having been reversed to bring the h.p. inlet next to the l.p. cylinder. The steam chest is cast integrally with the bottom half h.p. casing, and the combined inlet and emergency stop valve is arranged below floor level so that the top half casing can be removed without breaking steam pipe connections to the machine. A device is fitted on each machine to reduce the load automatically if condenser vacuum fails. Bursting discs are provided on the top-half l.p. casing hoods to prevent excessive pressures from being built up. Each boiler and turbine operates as a unit, with regard both to the steam and the feed systems.

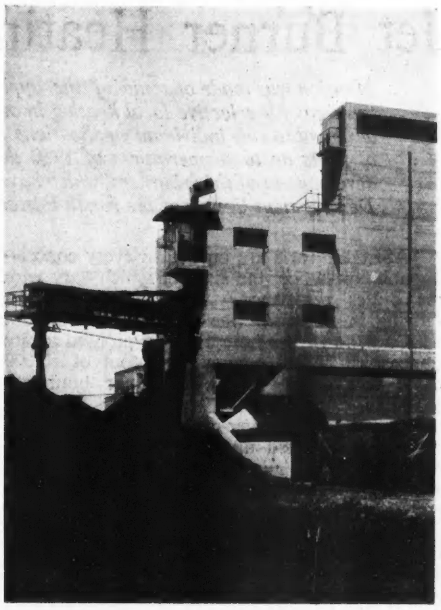
The mechanical governor and the main oil pump are driven from the h.p. rotor by a hollow quill shaft permitting accurate meshing of the worm and spur gear in spite of the misalignment that may arise relative to the rotor. An oil relay is operated by the governor. When the speed rises to 3300 r.p.m. the emergency governor (also mechanical) operates through the oil relay to cut off the steam supply by closing the governor and emergency stop valves. An auxiliary pump, driven by an a.c. motor, supplies oil to the bearings and governor gear during starting, shutting down, and barring (motor barring gear is installed). This pump cuts in automatically if the main pump pressure falls below a certain value. An additional pump, driven by a d.c. motor, stands by to provide oil for the bearings should the a.c.-motor-driven pump fail. Three lubricating oil coolers serve each set ; the coolant is taken from the condenser circulating water culverts. A motor-driven centrifuge on each set purifies the oil.

The h.p. and l.p. heaters are arranged on either side of the turbine foundation block. A burst tube in any of the h.p. heaters causes an electro-mechanical device automatically to divert feed water from the heaters.

There are two main three-stage, steam-operated, air ejectors, with an additional quick-start ejector for initial evacuation. The condenser is of the surface type, and is supported on springs. Each condenser consists of two shells connected in parallel and coupled directly to the double-flow l.p. turbine exhaust flange. A conductivity meter indicates the purity of the condensate, and another instrument shows the concentration of dissolved oxygen.

Mechano-hydraulic indicators of shaft eccentricity and axial movement are fitted. All the main bearings are of the liner type, and quick renewal is possible without effect on alignment.

The alternators are standard air-cooled machines wound for 11·8kV, 50 c/s, three-phase working, and each is complete with a direct-coupled double set consisting of a main and a pilot exciter. Alternator voltage is automatically controlled. Each alternator is air cooled by duplicated equipment, so that any one cooler can be cleaned while full load is borne. Cooling is by means of fans mounted on the rotor of the alternator. They circulate air through a finned-tube cooler in the foundation block. The cooling water comes from the circulating water system.



The tippler house is equipped with two electrically operated, side discharge tipplers of 250 tons per hour capacity each. Wagons with coal capacity up to 240 tons are handled

The circulating water system is arranged so that the requirements of the station are met by the river and the cooling towers in conjunction. The river flow is adequate for the cooling of one turbine under average conditions, and the cooling towers provide the capacity for another five. There are six vertical spindle, split casing, centrifugal c.w. pumps. Their rating is 22,000 gallons per minute, and they have a discharge head of 37ft.

PLANT CONTROL AND AUXILIARY SUPPLIES

A central control room in the administration block controls the output from the generators, the electrical services on the station, and the outgoing feeders from the station. One control panel for each pair of boiler turbine units is provided at operating floor level between the boilers and turbines. These control panels contain all the equipment required for the operation of the boilers and turbines, and effectively the plant is controlled from them (unless exceptional circumstances arise).

Electrically, each boiler and turbine is operated as a unit, and essential supplies are drawn from the unit transformers directly connected to the alternator. Auxiliary transformers are sited beside the turbine house facing the 132kV switching compound shown in our illustration. All station supplies, and supplies to non-essential auxiliaries, are obtained from 5MVA, 132/3·3kV, O/N station transformers. Oil-break and switch-fuse switchgear (3·3kV and 0·415kV) is installed in annexes adjoining the turbine house and boiler house.

PRINCIPAL CONTRACTORS

Access roads, Taylor Woodrow Construction, Ltd.; foundations and superstructure, Mitchell Construction Company ; structural steelwork, John Booth and Sons (Bolton), Ltd.; cooling towers, Film Cooling Towers (1925), Ltd.; chimneys, Bierrum and Partners, Ltd.; circulating water pumps and booster pumps, W. H. Allen, Sons and Co., Ltd.; circulating water penstocks and screens, William E. Farrer, Ltd.; water valves, J. Blakeborough and Sons, Ltd.; boiler plant, Clarke, Chapman and Co., Ltd.; instrumentation and automatic boiler control, Electroflo Meters Company, Ltd.; turbo-alternators, British Thomson-Houston Company, Ltd.; condensing and feed heating, G. and J. Weir, Ltd.; turbine house crane, Clyde Crane and Engineering Company ; auxiliary cranes, The Wharton Crane and Hoist Company, Ltd., and Herbert Morris, Ltd.; boiler feed pumps, Mather and Platt, Ltd.; coal handling plant, International Combustion, Ltd.; ash and dust handling plant, B.V.C. Industrial Constructions, Ltd.; h.p. and l.p. pipework, Stewarts and Lloyds, Ltd.; h.p. valves and mountings, Hopkinsons, Ltd., and Dewrance and Co., Ltd.; l.p. valves, Sir W. H. Bailey and Co., Ltd.; chlorinating plant, Paterson Engineering Company, Ltd.; shunting locomotives, Andrew Barclay, Sons and Co., Ltd.; water treatment plant, The Permutit Company, Ltd.; vacuum cleaning plant, Sturtevant Engineering Company, Ltd.; generator and station transformers, Hackbridge and Hewittic Electric Company, Ltd.; auxiliary transformers, Bonar Long and Co., Ltd.; 3·3kV and 415V switchgear, A. Reyrolle and Co., Ltd.; station batteries and charging equipment, Chloride Batteries, Ltd.; 11kV and lower voltage cables, Malcolm and Allan (London), Ltd.; carbon dioxide fire-fighting equipment, The Walter Kidde Company, Ltd.; main lighting and heating installation, London Electricity Board ; lighting and plug point installation, control block and 132kV switching station, Rashleigh Phipps and Co., Ltd.; site lighting, Troughton and Young, Ltd.; water jet fire-fighting and alarm installation, Mather and Platt, Ltd.

Jet Burner Heating with Town Gas

Mention was made of some of the applications of high pressure jet burners using town gas for selective local heating in our issue of July 12 last. These burners are designed to suit individual applications and can be used for selective local heating of parts up to temperatures of 1750 deg. Cent. Some interesting notes on the development of these burners, which have since been received from the Industrial Gas Development Centre of the North Eastern Gas Board, are reproduced in this article.

GASEOUS fuels are burned in every conceivable appliance, the sizes of which vary with the duties performed. As a result, burners ranging in size from the small 0·2 cubic foot or 100 B.Th.U. per hour to the type used to fire Lancashire boilers having an output of 10,000 cubic feet or 5×10^6 B.Th.U. per hour are available.

The science of burner design has, up to recent years, concentrated upon improvements in the entrainment and mixing of air and gas and the attainment of the maximum rate of flame propagation throughout this mixture with minimum absorption of the pressure energies available in the gas, or gas and air streams. The rate at which combustion occurs is limited and, if the mixture volume issuing from the nozzle is too great, the flames will leave the burner and become extinguished. Under such conditions, flame speed is exceeded by the mixture speed. From the foregoing, it will be appreciated that the rate of combustion of a theoretical mixture is controlled by three major factors :

(1) The degree of admixture of any primary air supply with the gas.

(2) The rate at which air can diffuse into the gas from the atmosphere.

(3) Having now produced this mixture, the rate at which centres of combustion can become sufficiently close to unburned mixtures to promote their ignition.

The third factor is dependent, itself, upon such factors as area of flame envelope, temperature of combustible mixture, the initiation, breaking and branching of chain reactions which take place prior to actual visible ignition, and other complex factors, all of which can be said to be physical constants of the mixture and burner type. From this it would appear that the fastest possible rate of combustion where air and gas is premixed in theoretical proportions prior to the burner has been reached. If, however, the flames produced by such systems are surrounded by a refractory tunnel, a rapid increase in combustion rates occurs. This is illustrated in the Table I :

TABLE I

Burner type	Volume of gas burned, cu. ft per hr	Volume of flame, cu. ft	Combustion rate, B.Th.U. per cu. ft flame	Flame temp., deg. Cent.
Non-aerated ..	600	0·45	$0 \cdot 67 \times 10^6$	1750 to 1850
Aerated	600	0·65	$0 \cdot 45 \times 10^6$	
Air blast	600	0·145	$2 \cdot 07 \times 10^6$	
Tunnel burners ...	600	0·00345	115×10^6	
Lucas combustor used in aircraft jet engines	10,000	—	10×10^6	

By what mechanism is the combustion rate increased under these conditions ? Unfortunately, we do not have the full answer, but an examination of the possible factors influencing combustion may be helpful to us. Early workers[1] on this type of combustion came to the conclusion that the increase in combustion rate was primarily influenced by a catalytic reaction taking place along the refractory wall, exciting increased centres of combustion which would naturally lead to the more intense combustion as illustrated in the "porous bed" type of mechanism.

Leason,[2] working at Leeds University, showed, however, that even at these high velocities the tunnel walls held round them a cool zone or "a dead space," although, when compared with that of the normal Bunsen or air blast type of burner, it is much reduced in thickness. From temperature measurement and velocity distributions he concluded that the mechanism of combustion differed little from the more conventional systems and that the refractory tunnel merely provided an incandescent ring at the base of the tunnel, stabilising the reaction. The turbulent conditions present within the tunnel gave rise to an increased flame area accelerating the progress of the flame front.

Howland and Simmonds,[3] working for the Gas Research Board, found that in other types of burner systems, turbulence equal in intensity to that found in tunnel burners did not produce the high rate of combustion per unit flame volume. They examined other factors likely to produce this increased rate of combustion, i.e. a rapid heating of the air/gas mixture by radiation from the tunnel walls. This was, however, eliminated as the time available was insufficient to materially influence the reaction. The effect of light beams on air/gas mixtures was then studied as Norrish[4] had shown ethylene combustion could be accelerated under the influence of light waves of some 3600 A. wavelength, but, as only small quantities of light of this wavelength could be recorded as emitted from the tunnel wall and intense light had little influence on the normal Bunsen cone, they concluded that its effects on tunnel combustion were negligible. They also found from stroboscopic examination of the flame that combustion took place as a series of explosions at high velocity and proved by spectrograph that the emission from the flame front is not typical of normal turbulent combustion, proving combustion to be of a very special nature.

Why the explosive combustion should take place is not altogether clear, and a short account of the combustion of static air/gas mixtures would possibly throw some light on the problem. If a mixture of air and gas is exploded by means of a spark in a tube open at one end, the resultant flame travels from the closed end of the tube at a uniform velocity. Under suitable conditions, it would then pass through a transition period of vibrational movement which accelerates to detonation where sonic velocities are attained. In the second stage of explosion, acceleration of the flame front takes place and a high concentration of shock waves, which have long been associated with ignition phenomena, are found to be present in the tube. It is possible that, under the influence of shock waves, the flame front is accelerated, retarded or even extinguished. These shock waves are produced by external means, such as a spark ignition, or can be produced spontaneously in, or just behind, the flame front. Under favourable conditions, the flame front can attain sufficient velocity to produce a highly luminous wave with the accompanying sound characteristic of detonation.

From such a conception, the rapid increase in combustion rate occurring by surrounding a flame with a refractory tunnel can be explained, namely, when combustion takes place, compression waves are radiated from a point at the base of the tunnel and are reflected by its walls and, upon striking the flame front, they cause an increase in flame speed.

The presence of shock waves is abundantly clear from the high noise level produced by a tunnel burner. These sound waves are sufficient in magnitude to produce a deafening resonance of the whole gas stream within the tunnel. Research into sound production is now in progress at Leeds University, which, when completed, will, it is hoped, throw further light on this problem and possibly establish a definite theory of the mechanism of jet burner combustion.

PRACTICAL ADVANTAGES OF JET BURNERS

The rate at which heat can be transmitted to a solid surface by a gas flame is governed by two major factors :

(1) Radiation from the flame.

(2) Convection currents created by the flame raising the temperature of the boundary layers held round such surfaces.

Although some heat processes at present use flame radiation as the primary source of heat transfer, convection is the major heat mechanism employed in the bulk of cases. Using convection for heat transmission, products resulting from the combustion of the air/gas mixture, at some 1850 deg. Cent., are impinged on the material to be heated. Looking closely into the impact of hot gases on to a cool surface, it is found that actual contact between these gases and the surface does not, in fact, take place, but rather do they pass their heat to a layer of stagnant gases held on the surface raising the temperature of this layer, which, in turn, passes heat to the material being heated. Thus, it will be seen that the rate at which heat transfer can take place is dependent upon three major factors :

(1) Heat transfer coefficient of this boundary layer.

(2) Temperature gradient across the layer.

(3) The thickness of the layer itself.

From this it will be realised that the thickness of the boundary layer is decreased by increasing the velocity of impact of the gases issuing from a burner.

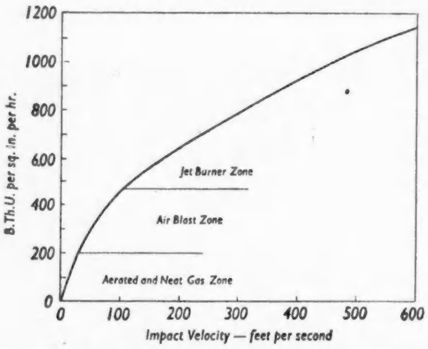


Fig. 1—Heating potential of jet burner compared with that of a normal aerated burner

From Fig. 1 it will be seen that the heat potential of a burner is not merely dependent upon the temperature of the stream of products issuing from it, but also upon the velocity or kinetic energy of this stream. In normal systems, thermal expansion due to combustion of the mixture takes place in three dimensions and the resultant hot stream of products is increased little in velocity by this expansion. If the flame is then surrounded by a refractory tunnel of divergent or parallel cross section as in the normal tunnel burner, the expansion of products is restrained and much greater discharge velocities are achieved with an accompanying increase in the heating potentialities of the burner.

In the jet burner, however, not only is a three-dimensional expansion obviated, but also, upon completing the combustion, the flow rate of the products up the tunnel to the point at which they are discharged to the atmosphere is accelerated. This is accomplished by using a convergent tunnel cross section. By the use of this convergent section, discharge velocities greater than 1000 m.p.h. have been achieved. From Fig. 1 the heating potential can be seen to be some fifteen times greater with a jet burner than with the normal aerated burner. (This figure has been compiled from tests carried out at the Industrial Development Centre at Bradford.) Whilst heat input is shown to be vastly greater

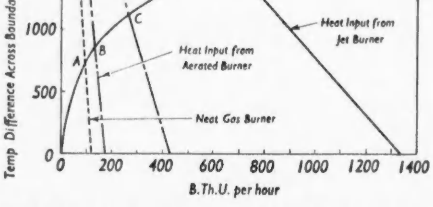


Fig. 2—Heat losses from a 1in cube of steel by radiation as its temperature increases, and rate at which heat can be given up to the cube by different burner systems

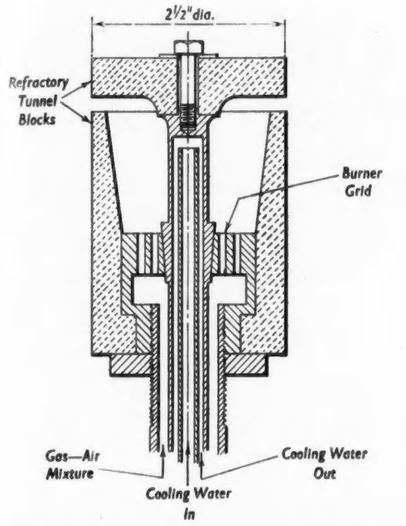


Fig. 3—Small internal valve-heating burner

with jet type burners, the heat losses from the body being heated are the same regardless of the rate of heating and are the sum of conduction losses from the area being heated through the material itself and radiation losses. In Fig. 2 the heat losses from a 1in cube of steel by radiation, as its temperature increases, are illustrated.

Superimposed upon this curve is the rate at which heat can be given up to the cube by a jet of products from different burner systems impinging on one face of the cube. At the point of intersection of the curves, i.e. *A*, *B*, *C*, *D*, the heat input is equal to the radiant losses. The temperature at which this equilibrium is attained is of the greatest importance: much greater temperatures can be achieved by the use of jet type combustion with its characteristic high velocity of waste gas impact on the surface being heated. The times taken to reach this equilibrium and the temperature at which it is established are shown in Table II and illustrate the remarkable results obtainable by this jet burner heating.

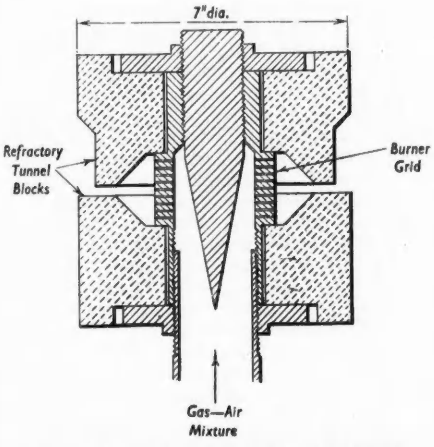


Fig. 4—Large internal valve-heating burner

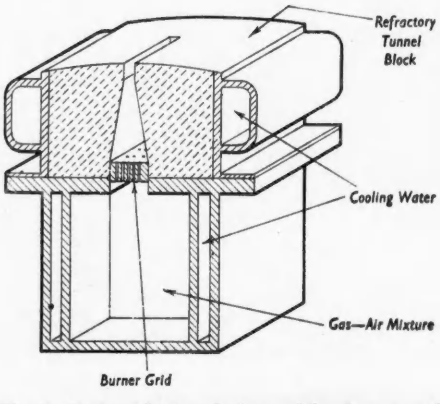


Fig. 5—Design of internal plate welding burner used on pipe lap welding machine

TABLE II

	Temp. attained at equilibrium, deg. Fah.	Heat required to raise metal cube to equilibrium, B.Th.U.	Velocity of products on to one face of cube, ft per sec	Heating time required to reach equilibrium, min
Jet burner	1520	46·0	754·0	3·1
Air blast ...	1100	33·3	56·8	7·2
Aerated ...	810	24·6	24·7	12·3
Neat gas ...	690	20·9	18·7	17·5

PRACTICAL ADVANTAGES OF JET BURNERS

By the reduction in heating times and the higher temperatures attained, as illustrated in Table II, the necessity of surrounding the work to be heated with an insulating refractory chamber to prevent heat losses has been much reduced.

It is possible now, by the use of tunnel burners positioned correctly, to heat only a small portion of a complex structure without materially raising the temperature of the bulk of the piece, and a striking example of this is the preheating of valve seats prior to metal deposition. By the use of correctly positioned jet burners, shown in Figs. 3 and 4, internal seats of valves weighing up to 2¼ tons can be raised to a temperature of 750 deg. Cent. in some twelve minutes, although this seat is situated within a highly conductive structure. From this it can be realised that large production economies are likely when this unconventional method of heating is adopted.

A further illustration of the remarkable achievements of jet burner heating was demonstrated in the lap welding processes used by Clayton, Son and Co., Ltd., for the production of high quality large diameter steel tubing. Plate is rolled to form a ½in lap joint, which joint is then heated to some 1500 deg. Cent. and rolled under a pressure of 12·5 tons. Under the influence of this temperature and pressure, a weld of high quality is made. Since the attainment of this temperature, namely, 1500 deg. Cent. in open atmosphere, is not possible with coal gas/air mixture in conventional burners, very large jet burners had to be designed, and these are illustrated in Figs. 5 and 6 and seen in action in Fig. 7. Although apparently simple in construction, many problems have to be overcome in the production of jet burners, particularly in burners of these dimensions where up to 4000 cubic feet per hour of coal gas has to be burned within the limited combustion space of 0·026 cubic foot.

In the past, efforts have been made to standardise burners, but in jet burners where the maximum point of heat release is only some 1in from the burner mouth, burners must be "tailor-made" to the job in hand. If this is to be done, then the use of prefired blocks with the accompanying high pattern costs involved must be dispensed with and materials suitable for ramming or casting used instead. As many of the latter brands are available, it would appear that a very wide choice exists, but, whilst these are very excellent for smaller parallel sided or divergent tunnels, all are not suitable for jet burners with convergent tunnels. A short list of the arduous duties and required properties may help to illustrate this point :

(1) The material must not subside or lose strength at temperatures as high as 1750 deg. Cent.

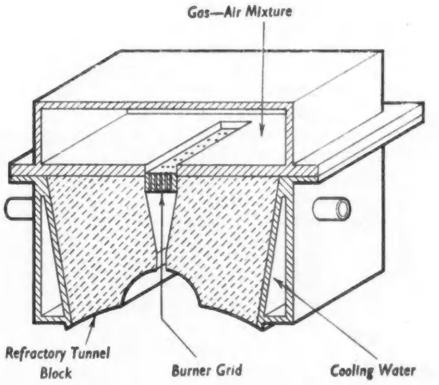


Fig. 6—Design of external plate welding burner for pipe lap welding machine

(2) The material should resist thermal shock since tunnel working temperature is attained in some thirty seconds.

(3) The fired and unfired mechanical strength of the material should be as high as possible as curing of the refractory is never completed in a tunnel and in the outer layers the material may rely upon unfired strength.

(4) Volume stability is also of great importance, as will be realised from the previous requirement. If curing is incomplete any shrinkage or growth on firing will result in distortion with its resultant cracking.

(5) Thermal conductivity should be low to reduce the inevitable burner losses to a minimum, and also because materials of high thermal conductivity will cause overheating of the perforated back plate, which may, in turn, promote ignition of the mixture behind this plate, should the mixture velocity fall.

In view of the foregoing, the choice appears to be limited to those having the following constitution :—

Alumina	Greater than 60 per cent
Silica	Less than 36 per cent
Impurities and alkali	Less than 3 per cent

The grog size should be large and widely graded to give low shrinkage and high density.

The second and most serious problem with very large burners is the noise produced. As previously stated, the tunnel length is of prime importance in prevention of noise, although many other factors are found to influence noise production. The major components of the burner that may influence noise are the metal or ceramic back plate, tunnel form, tunnel material, and tunnel exit.

A study of these factors has led to the following rather empirical conclusions :—

(*a*) The susceptibility of a tunnel to resonance has been found to depend upon the size of the

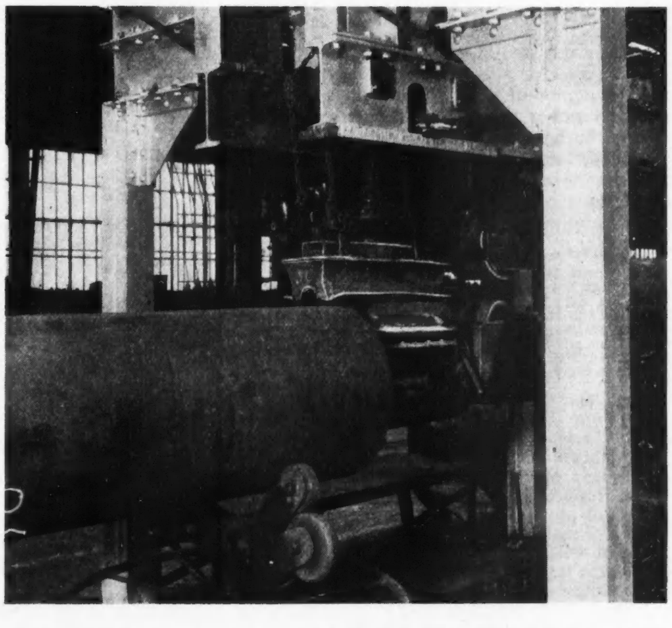


Fig. 7—Jet burners for town gas fitted on large pipe lap welding machine

perforations through which the gas and air mixture passes. The larger these perforations, the less likely is the tunnel to resonate, as the flame front is reduced in area and is consequently positioned nearer the tunnel mouth. The size to which perforations can be increased depends upon the degree of turn down required, as the danger of burner light back is increased.

(*b*) The basic tunnel form or section is of great importance if resonance is to be avoided and the following general principles have been used as a guide :

(i) The parallel sided tunnel form should, whenever possible, be avoided as stabilisation of the combustion is difficult within these parallel sections.

(ii) The tunnel with a convergent section, having constant taper to reduce reflection of sound shock waves within the tunnel, provides the greatest stability.

(iii) 10 deg. to 20 deg. convergent taper is found most satisfactory, but this is rather dependent upon the exit velocity required.

(iv) Stagnant pockets of gas or areas of low velocity should be reduced to a minimum as turbulence created by these pockets may again cause instability.

(v) It is important that burners be designed for the particular purpose for which they are required, as is the general rule in all furnace work.

(vi) Excess tunnel volume should never be permitted because resonance is favoured by such conditions. The burner efficiency—that is, heat to work—suffers seriously in a turned down or an over-tunnelled condition.

(*c*) In addition to the refractory properties previously mentioned, the nature of the tunnel surface produced by a material is of importance in the prevention of resonance. It has been found that the smoother the material, the more likely it is to resonate due, most probably, to the absorption of shock waves by a rougher material.

CLAYTON BURNERS

Burners were constructed to fit in with the above principles for the lap welding machine previously mentioned. Gas at 2 lb per square inch and air at 2·5 lb per square inch were provided by a compressing plant with the burners positioned in the machine as shown in Fig. 7. A preliminary test revealed the following results :—

	Coal gas	Water gas
Plate thickness	$\frac{9}{16}$in	$\frac{9}{16}$in
Tube length	22·8ft ...	22·8ft
Total time taken to weld pipe...	95·5 min ...	139 min
Tube diameter	27in ...	27in
Handling time (approx.) ...	20 min ...	20 min
Welding time	75·5 min ...	119 min
Time taken to reach 1500° on first heat	2·5 min (approx.)	4·25 min
Length of weld per hour ...	14·3ft ...	10·2ft
Gas rate	5,600 cu. ft/hr ...	12,600 cu. ft/hr
Gas used per foot of tube welded	395 cu. ft ...	1,230 cu. ft
Relative cost of fuel per foot	1 ...	2

There appears to be no reason why similar results should not be obtained in many applications of these burners where they are designed to replace the more traditional systems, and also why their use should not be extended to other process jobs for which fuels other than coal gas are at present used. The examples quoted, although rather specialised, show that, in this type of burner, where heating potentials are a product of temperature and high velocity, coal gas can be used to provide a heat-treatment service at a much lower all-in cost to industry than has hitherto been possible.

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[4] Norrish and Patnaik, *Nature*, 1949, 163, 883.

GRID-CONTROLLED INDUCTION HEATERS.—Induction heaters of 9kW, 15kW and 25kW, made by Radio Heaters, Ltd., Wokingham, Berkshire, are claimed to provide infinitely variable outputs independent of mains fluctuations over the whole range of output variation (20 : 1). Standard sets work on three-phase supplies of 360V to 440V, 50 c/s, but other voltages or frequencies can be catered for. The equipments are said to be suitable for processes where accurate control of heat output is required.

Power Station and Ore Handling Plant at a Scottish Steel Works

On page 159 of our issue of August 2, there appear some illustrations and a brief description of the iron and steel plant at Ravenscraig, Motherwell, which has just been put into operation by Colvilles, Ltd. Below we refer to the works power station and the ore-handling plant at the General Terminus Quay, Glasgow.

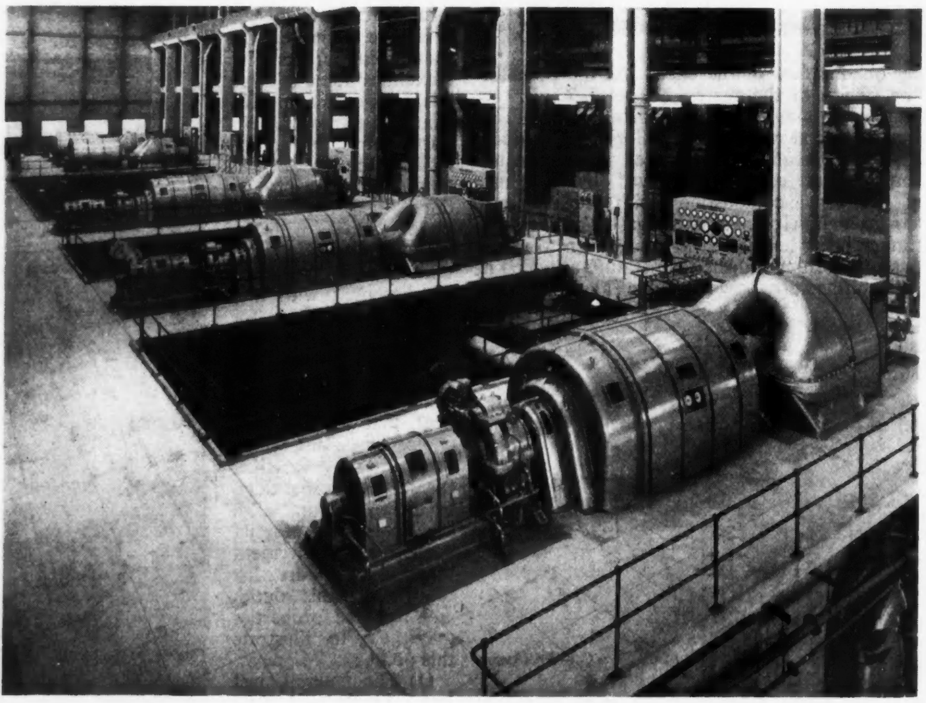
THE Ravenscraig Works of Colvilles, Ltd., include a blast-furnace, two batteries of coke ovens (thirty-five in each), a by-products plant and a steel melting shop, all of which are now operating. Further developments on the same site are already planned. The initial output of the works will be about 400,000 ingot tons of steel a year.

The main contractor for the works power station was The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. This company was responsible for all the mechanical and electrical plant and equipment installed, including the boilers, turbo-generating plant, switchgear and furnace blowers, as well as for all the civil engineering work associated with the power station building and the two cooling towers. The station is interconnected with the South of Scotland Electricity Board's 33kV grid, from which power will be drawn, when necessary, to supplement the 30MW installed capacity. Distribution at 33kV is also carried out from the station to the nearby Dazell Works, Lanarkshire Steel Works, and Clyde Alloy Steel Works, all of which are in the Colvilles group. In addition to electrical services, the station supplies process steam to the coke ovens, melting shop and blast-furnace, as well as heating steam for the main administration block and cold blast to the furnace.

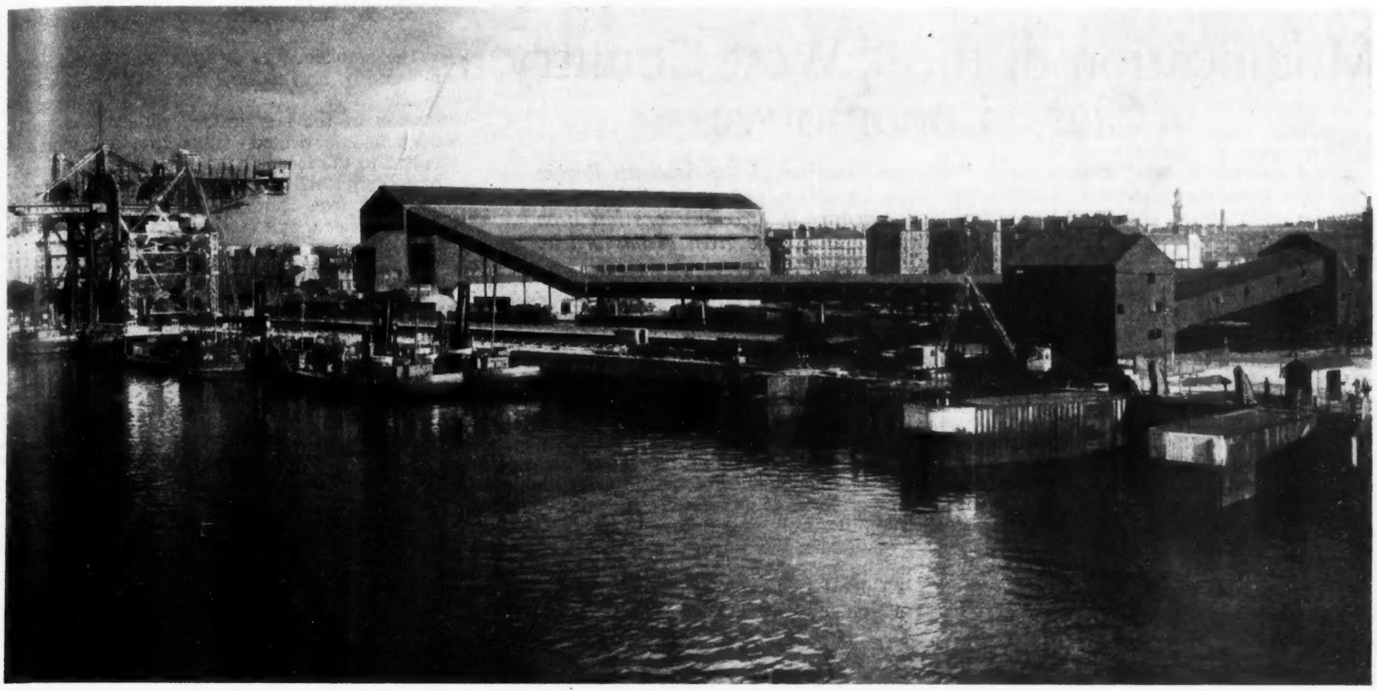
As at present installed, the power plant consists of three G.E.C. 10MW, 3000 r.p.m., turbo-generators, as illustrated herewith, and two 90,000 cubic feet per minute turbo-blowers. Four Babcock and Wilcox bi-drum boilers with water-cooled furnaces are installed, each having a maximum continuous rating of 125,000 lb of steam per hour. Normally, only three of them will be in operation at a time, with one acting as a standby ; the boilers are arranged for blast gas firing with oil fuel as an alternative in the event of no blast-furnace gas being available. Provision has also been made for conversion to solid fuel if required at a future date, the necessary conveyor, bunker, stoker and ash disposal plant having been allowed for in the design of the station. Furthermore, although at present there are only three turbo-alternators, provision has been made to accommodate another set when extensions at Ravenscraig are undertaken.

The turbo-alternators are designed for steam conditions of 400 lb per square inch gauge at 800 deg. Fah., each with an output of 10MW (M.C.R.) at 11kV, 50 c/s, three-phase. At present, one of the sets (No. 3) is modified to operate on steam supplied from the melting shop waste heat boilers at 250 lb per square inch gauge at 700 deg. Fah., and under these lower conditions it has an output of 8650kW. This will be increased to its designed figure when small modifications are made and it is put into operation with normal steam conditions at the time of installing the fourth machine. The two 90,000 cubic feet per minute turbine-driven centrifugal blowers also operate from the main steam supply of 400 lb per square inch gauge at 800 deg. Fah. They deliver air to the blast-furnace at 32 lb per square inch gauge maximum and are designed for high top-pressure working on the furnace. The blowers have a hydraulic governor system incorporating an " Askania " constant-volume control with an anti-surge regulator. Either one of these units has ample capacity to meet the requirements of the single blast-furnace, so that the other machine is always available as a standby. Here, again, provision has been made for the installation of another similar set at a future date.

The process steam for use in the coke ovens by-product plant and for liquid fuel atomisation at the melting shop is obtained from simple back-pressure impulse turbines which are used to drive the circulating water pumps. The steam inlet conditions are the same as for the main turbine-driven sets, i.e. 400 lb per square inch gauge at 800 deg. Fah., and the exhaust steam is at 160 lb per square inch gauge at 660 deg. Fah. At an early stage in the design it was decided to drive the circulating water pumps by relatively small steam turbines and use these as a source of process steam. This arrangement, it is claimed, results in extreme flexibility and allows inexpen-



Ravenscraig power station interior. The three 10MW turbo-generators are shown in the foreground ; at the far end of the station are the two 90,000 cubic feet per minute centrifugal turbo-blowers



Ore unloading and conveying equipment at the General Terminus Quay, Glasgow

sive modification to small turbines to suit widely different steam demands as they become evident in subsequent phases of development of the plants. There are two turbine-driven circulating water pump sets, each turbine being coupled through reduction gearing to two circulating water pumps in tandem. Either of these sets is capable of supplying the cooling water for any three of the turbo-alternators or turbo-blowers, while the other pump provides the jacket cooling water for the blast-furnace. Should more than three main sets be running at the same time, the balance of circulating water required is provided by motor-driven pumps. Each of the main pump sets has a capacity of 24,885 gallons per minute against a 60ft head.

From an electrical point of view, the station is interconnected with the 33kV grid of the South of Scotland Electricity Board so that power can be imported or exported, depending upon the demands at Ravenscraig. This is effected through a ten-panel, 33kV, 750MVA, single-busbar metal-clad switchboard, which also serves to control the 33kV feeders to the other nearby plants of Colvilles, Ltd. The 11kV output from the turbo-alternators is controlled by an eleven-panel switchboard of 350MVA rating, which also connects the 11kV and 33kV busbars through two 20MVA, 33/11kV transformers with on-load tap-changing equipment. Distribution within the Ravenscraig Works is carried out at 11kV, and 250MVA switchgear has been provided for this purpose. This is an eighteen-panel board and controls the outgoing feeders for the h.v. distribution system as well as the transformers for the l.v. 440V supplies. The control room, with wide panoramic views of the whole of the inside of the station, measures 100ft by 20ft and accommodates the control boards, relay boards, and the busbar protection boards for all the 33kV and 11kV switchgear. For various auxiliary services in the station, the G.E.C. has supplied sixty-nine electric motor drives, with a total horsepower of 2775, in addition to many larger motors.

ORE HANDLING AT GENERAL TERMINUS QUAY

The blast-furnace at Ravenscraig has been designed to operate on high-grade imported ore. It was therefore essential, in the planning of the project, to provide adequately for unloading ore carriers at the General Terminus Quay, Glasgow, and transporting the ore to Ravenscraig. The quay, which is situated in the lower harbour on the south bank of the Clyde immediately above Finnieston Ferry, has been reconstructed to accommodate ore carriers up to 15,600 tons capacity. Three travelling transporters, each with a capacity of 600 tons per hour, unload the ships and transfer the ore to a conveyor system which carries it over a road bordering the quay to two long bunkers on the other side. From them are loaded the trains which take the ore to the Ravenscraig plant and to the Clyde Iron Works. Our second illustration shows the layout of the plant. The conveyor system was supplied and erected by the Fraser and Chalmers Engineering Works of The General Electric Company, Ltd.; it consists essentially of two lines of 48in conveyor belts in four sections, each belt having a capacity of 1000 tons per hour at 300ft per minute.

The first section of the system consists of conveyors Nos. 1 and 2, each about 1000ft long between head and tail-pulley centres. The belts run side by side along the whole length of the quay occupied by the ship and rise beyond it to junction house No. 1 at the side of the road. One belt can take the discharge of any two transporters, which deliver the ore into hoppers and thence on to the belt by variable-speed apron feeders. The speed can be regulated according to the density of the ore so that the load on the conveyor does not exceed 1000 tons per hour. The hopper-feeder unit is an integral part of the transporter. In junction house No. 1 the ore is transferred to 60in belt feeders, the purpose of which is to even out its distribution before delivering it to conveyors Nos. 1A and 2A, respectively. These run at right angles to the quayside belts at an upward slope over the road to junction house No. 2. There the ore is transferred to conveyors Nos. 1B and 2B, which take it to the bunkers. They travel back some 740ft parallel with the road (and parallel with the quayside conveyors), rising to a height of 80ft above ground level at the far end in order to drop the ore onto conveyors Nos. 1C and 2C, which extend over the whole length of the double row of bunkers, one over each row. Each conveyor has a belt-operated, hand-controlled tripper for discharging the ore at the required spot in the bunkers. The bunkers are 325ft long and the top is about 70ft above ground. They hold a total of 14,000 tons of ore. The sides of the bunkers are sloped and at the bottom of each there are two rows of fifty-six double-lip down-cut discharge gates, arranged in pairs. Under the gates and about 10ft below them are four rows of hoppers, each hopper being centred under a pair of gates and having a capacity of 17½ tons of ore. Four rail tracks are laid over the hoppers under the rows of bunker gates, and on each track runs a scale car. The operator draws 17½ tons of ore at a time from the bunkers into the car and discharges the load into one of the hoppers below, until the whole row is full. Railway lines run under each of the four rows of hoppers and are so arranged that two adjacent hoppers are directly over one ore wagon when a train is in the loading position.

The ore trains consist of twenty-eight 35-ton hand-operated, central bottom-discharging wagons. When a train is to be loaded, it is uncoupled in the middle and each section of fourteen wagons is run in under one of the rows of hoppers until it is in contact with the buffers at the far end. In this position, as mentioned earlier, each wagon is located under two hoppers, each containing 17½ tons of ore. The hopper gates are opened and closed by a hydraulic system so designed that, by the turn of a valve, all the hoppers in one row can be emptied simultaneously in less than a minute into the wagons below, which are then ready to be pulled out and coupled up to the other half of the train for despatch to one of the furnace plants. Another turn of the valve closes the gates and the hoppers are ready to be filled again. Standard three-pulley troughing idlers with roller bearings are provided with rubber disc and return idlers and standard tubular idlers at intervals to assist in training the belts. All the conveyors are driven by G.E.C. motors through worm reduction gears and fluid couplings. Control gear is mounted near the respective motors and it is all interlocked so that no belt can be started until the one following it is running. Each pair of belts is contained in a common gallery with walkways, 3ft wide, between them and on each side, and with hand-rails on the outside. On the outer side of each conveyor is a trip wire by which the whole system can be stopped in an emergency from any point.

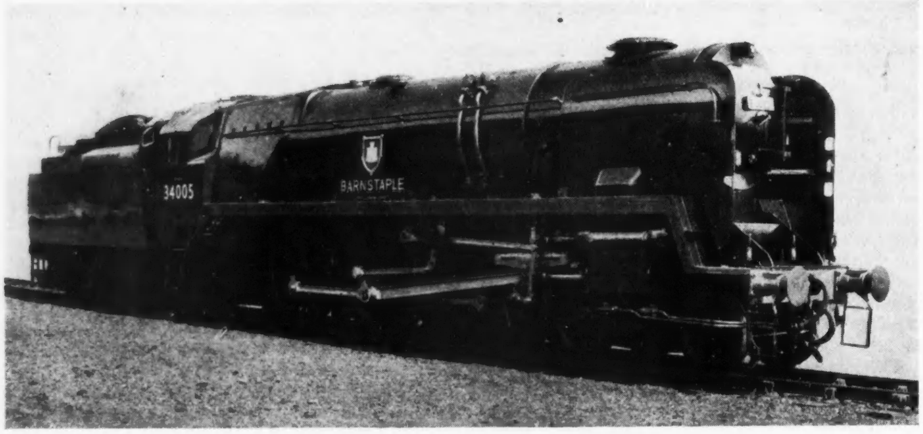
Prototype Electronic Telephone Exchange

IT is expected that the first all-electronic telephone exchange, now in an advanced stage of design, will be opened in the North London telephone area known as Highgate Wood in March, 1960. This fully automatic prototype, it is hoped, will help to provide useful data and experience. The exchange is intended to give the same facilities as the present mechanical system to over a thousand subscribers. The absence of moving parts or mechanical contacts is expected to eliminate much wear and tear, and, once some of the practical problems have been solved, greater economy is anticipated than is obtained with mechanical exchanges.

Electronic directors for routing calls in London have worked successfully at the Richmond exchange for five years, and improved equipment of the same kind will shortly be used at Lee Green, in south-east London. Electronic routing and charging are planned for the Bristol trunk-dialling system, due for service in 1959.

Modification of the "West Country" Class Locomotive

A number of the "West Country" class locomotives of the Southern Region are being modified on similar lines to the work carried out on the "Merchant Navy" class. The first locomotive to incorporate the modifications has been completed and some particulars of the work involved are given in this article.



Modified "West Country" class locomotive for the Southern Region of British Railways

PARTICULARS have been received from the Southern Region of modifications which are being made to a number of the "West Country" class locomotives which were introduced on the Southern Railway in 1945. These engines, it will be recalled, were a lightweight version of Mr. O. V. S. Bulleid's "Merchant Navy" class "Pacific" locomotives and 110 of them were put in service between 1945 and 1951. They incorporated most of the same design features as did the "Merchant Navy" class locomotives when built, a number of which are not normally employed in British locomotive practice. Among these features were :

(i) A three-throw crankshaft, chain driven from the driving axle, which operated valve gear for each of the three cylinders. Each gear was connected to its respective piston valve through a rocking lever arrangement having a 3: 8 ratio.

(ii) An oil bath enclosing the three sets of special valve gear and the inside motion. This was intended to give continuous lubrication to the working parts.

(iii) A smokebox of irregular shape, as opposed to the more usual cylindrical form.

(iv) Special casing over the whole of the upper part of the locomotive.

As was the case with the "Merchant Navy" locomotives these features have not proved to be completely satisfactory and this in turn has reflected on performance as well as on maintenance. Additionally, consumption of coal, oil and water has been fairly high.

The locomotives concerned are being modified on similar lines to the "Merchant Navy" class, in accordance with the designs prepared at Brighton under the direction of Mr. W. J. A. Sykes, chief mechanical and electrical engineer, Southern Region, in consultation with Mr. R. C. Bond, chief mechanical engineer, British Railways Central Staff, British Transport Commission. The work of preparing the new details is being carried out mainly at Eastleigh Locomotive Works with assistance from Ashford Works. Locomotive No. 34005, "Barnstaple," which has been modified, is illustrated herewith.

The three-cylinder arrangement has been retained with the cylinders in their former positions, driving on to the middle coupled axle. A new inside cylinder is provided, but the two existing outside cylinders have been re-used. The cylinder dimensions, 16⅜in diameter and 24in stroke, are the same as before and the piston valves remain at 10in diameter. The new inside cylinder is a steel casting having cast iron liners to both the cylinder barrel and the steam chest, the latter being offset to the right, and arranged for inside admission. The steam chests of the outside cylinders are placed on the same vertical centre line as the cylinders and are arranged for outside admission. The piston-rods are provided with "United Kingdom" cast iron packing, which is also used for the valve spindles of the outside cylinders ; experience on the modified "Merchant Navy" class has shown these packings to be entirely satisfactory for the high pressure gland made necessary by outside admission. The piston-rods are attached to the piston heads by a parallel fastening and to the new crossheads by the normal cone and cotter attachment.

The oil bath has been dispensed with, and the motion and valve gear of the inside cylinder are no longer completely enclosed, enabling the various working parts to be readily examined.

VALVE GEAR

The three independent sets of Walschaerts' valve gear fitted are almost exactly similar to the new valve gears fitted to the "Merchant Navy" class. The outside gears are arranged for outside admission to suit the existing cylinders and, due to the offset between the centre line of the valve gear and the axis of the steam chest, a suspension link is employed to carry the weight of the valve gear and eliminate the normal valve spindle crosshead guides. A short link connects the suspension link to the valve spindle crosshead. The piston valves for the outside cylinders have a maximum travel of 6¾in, and each head is fitted with four narrow rings. The return crank rod is attached to the return crank through a self-aligning ball bearing.

The inside valve gear is driven by an eccentric mounted on the right-hand crank web of the driving axle, being spigotted to the web and held in position by five studs. The valve gear, of orthodox design, is arranged for inside admission, the maximum travel being $6^{11}/_{32}$in. The steam reversing gear which was formerly fitted has been replaced by a manual reversing gear, the screw of which is located on a bracket attached to the outside of the main frame midway between the l.h. driving and trailing coupled wheels. This screw is driven from the cab by a shaft fitted with universal joints, the cab containing only the handle, spur gearing, locking gear and cut-off indicator. A short bridle rod connects the reversing screw nut to the reversing shaft ; the latter, having three arms, controls the three valve gears without the use of an intermediate reversing shaft. The handle in the cab is arranged "face-on" to the driver, and a drum cut-off indicator is fitted.

The smokebox of irregular shape has been replaced by a cylindrical smokebox resting on a saddle. This saddle is formed partly by the upper portion of the new inside cylinder and partly by a new fabricated saddle stretcher, which is bolted to the front of the cylinder casting. The multiple jet blast pipe has been retained, but a new cast iron chimney of large diameter has been provided, this being fitted with a petticoat and ejector exhaust ring. The casing which was formerly fitted over the whole of the upper part of the locomotive has been dispensed with, and the boiler is provided with the normal type of clothing plates mounted on crinolines.

No substantial alteration has been made to the boiler, which retains its steel firebox and thermic syphons. The former grate, which incorporated both rocking units and a "drop" section, and which has been found somewhat unreliable in service, has been replaced with the type of grate used on the B.R. Standard locomotives, having unit firebars which are assembled on their respective carrier bars by sliding into position. The rocking sections are divided into two groups which can be rocked separately.

The ashpan previously fitted to the majority of the "West Country" class locomotives was without damper doors, permanent openings being provided for the inlet of air to the grate. Whilst simplifying the construction of the ashpan and eliminating damper doors and operating gear, this arrangement has, on occasion, made the control of the fire and the prevention of blowing off at the safety valves somewhat difficult. A new ashpan is provided with damper doors and standard butterfly doors at the bottom for self-emptying. The ashpan is divided into three parts, there being a central section between the frames, and two outer sections, all three being in the form of hoppers. One damper door facing forwards is applied to each of the three sections. The three damper doors are in line, and are connected to a transverse operating shaft fitted with a simple universal joint in order to eliminate any tightness which might be caused by slight distortion of the ashpan. A similar arrangement is applied to the hopper doors at the bottom, which are operated from the ground by a short lever which takes the same bar as that used for operating the rocking grate. The damper doors are operated by a single screw control on the footplate.

Two Wakefield mechanical lubricators on the footplating over the leading pair of coupled wheels on each side of the locomotive are driven by a short arm mounted on the outside expansion links. Three of these lubricators, each having six feeds, have been removed from their former position in front of the smokebox and are used for supplying the cylinders and steam chests with superheater cylinder oil. The remaining lubricator, which is fitted on the right-hand side of the engine, has twelve feeds and supplies engine oil to the axleboxes, &c. The oil to the steam chests is atomised and is introduced into the steam pipes feeding each of the three cylinders. The barrels are lubricated by non-atomised feeds passing through the cylinder walls near the vertical centre line at top and bottom. Other feeds pass to the piston-rod packing and the valve spindle rear bush. The coupled axleboxes are, at present, fed with engine oil at the crown but in due course, as the existing axleboxes have to be renewed, the feed will be transferred to the tray which accommodates the oil pad on the underside of the bearing.

The provision of mechanical feeds to the axleboxes eliminates the large multi-feed oilboxes formerly fitted in the cab. Mechanical feeds are also applied to the slidebars and the inside valve spindle crosshead guides. The axlebox guides and inside piston-rod swab box are lubricated by trimming feeds in small auxiliary oilboxes attached to the footplating, similar oilboxes adjacent to the point of application lubricating the outside piston-rod swab boxes. The majority of the valve gear is lubricated by grease.

Owing to the removal of the casing over the upper part of the locomotives, the previous sandboxes have been replaced by new ones, those for the leading pair of wheels being placed above the footplating adjacent to the back end of the smokebox, and those for the driving pair of wheels being between the frames. Steam sanding gear applied to the leading and driving coupled wheels is arranged for forward running. In addition, sandpipes are provided behind the driving wheels for reverse running, and replace the gravity sanding gear which was previously fitted to the front end of the tender for this purpose. Steam sanding is thus provided for both forward and reverse running.

The drawgear between engine and tender has been modified and incorporates a plunger, sliding in guides in the tender dragbox, which is pin-jointed to the drawbar itself. The plunger is controlled by a heavy rubber spring drawing the engine and tender together, and bringing the curved rubbing blocks into contact. These rubbing blocks, faced with manganese steel, are so shaped that relative lateral movement between engine and tender does not increase the loading of the drawbar and spring.

In full working order the modified locomotives weigh 90 tons and the two kinds of tenders to be used take 4500 or 5500 gallons of water and weigh 42 tons 12 cwt and 47 tons 5 cwt respectively when full. The locomotives now have a tractive effort of 27,720 lb.

Tricycle Row-crop Tractor

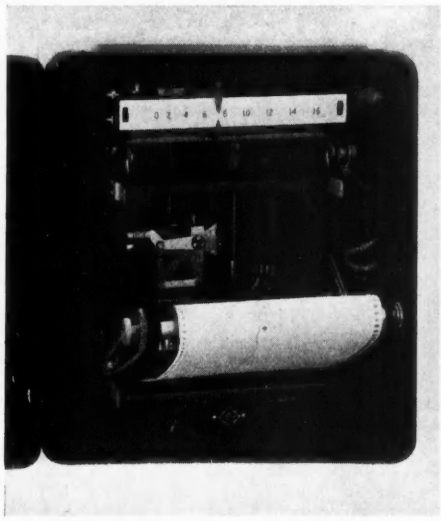
We illustrate below a tricycle row-crop tractor which has been introduced by the David Brown Tractor Division, Meltham, Huddersfield, after field testing in California. The tractor has been designed to suit the requirements of the North American market. It is based on the 40 h.p. diesel "900" which was described in our issue of November 30, 1956. The power unit is a four-cylinder, direct injection diesel engine, and the gearbox is arranged to give six forward speeds, between 1·67 and 15 miles an hour at 1850 r.p.m., and two reverse speeds of 6·6 and 2·28 miles an hour. The tractor, which is designated the "903," is equipped with a two-speed power take-off.

As this tractor is intended specially for row-crop cultivation work in maize, sugar cane and cotton, ample ground clearance is essential. By using 11 × 38in tyres for the back wheels, a clearance of 29in has been achieved. Adjustment of the rear wheels can be made in 4in steps from 52in to 80in, special attention having been paid to the provision of a bearing which will guard against infiltration of dust from the dry soil conditions in which the tractor will normally work. Similar protective measures have been taken in the design of the fuel system. Good use is made of the ground clearance and open space between the front and rear wheels by the mid-mounting of implements controlled through the tractor's hydraulic system. This is in addition to the normal rear three-point hydraulic linkage. In order to allow independent control of the rear and mid-mounted implements, the normal lift mechanism has been replaced by a twin selector valve in the hydraulic system and by two levers. On entering rows, the centre and rear implements can, therefore, be brought into work in succession at the same point and can be lifted in a similar way. For ploughing and trailer work, there is an adjustable drawbar, with the hitch point variable between 14in and 20¾in from the ground.

40 b.h.p. diesel "tricycle" tractor

Electronic Recorder-Controller

The "Model DE" Electronic Recorder made by Cambridge Instrument Company, Ltd., 13, Grosvenor Place, London, S.W.1, has been designed to measure any quantity that can be converted into a small direct current signal and employs a powerful closed-loop servo-mechanism of high sensitivity, accuracy and fast speed of response. Normal servicing comprises only pen filling, chart changing and periodical gear lubrication. The self-contained plug-in amplifier unit can be replaced within minutes, and the range changed on site by unsoldering and resoldering seven conveniently placed connections. Hand change gears select chart speeds ranging from ¼in per hour to 6in per minute. Standardisation is by means of dry cell or mains-operated stabilised supply unit against a built-in miniature standard cell.



Electronic recorder-controller arranged as a single point proportional pneumatic controller. The chart carriage has been pulled forward, revealing proportional unit and linkage (centre, left)

The standard potentiometric version, whether single or multi-point, is stated to respond to a change in input signal of less than 1μV for the minimum range of 1mV full scale, and record a full-scale error signal within two seconds. The overall accuracy is $\pm 5\mu$V and higher range instruments have the same relative accuracy and sensitivity. When arranged as a current balance, ranges down to $0{\cdot}2\mu$A can be provided.

The controller (see accompanying illustration) incorporates a mechanical error generating system with enough power to operate multiple switches, slidewires, magslips, pneumatic transmitters and other similar control devices. The necessary auxiliary equipment is designed on the unit principle and is mounted on a standard sub-chassis. Single-point instruments may have up to six independently adjustable cams operating S.P.C.O. micro-switches at predetermined recorder settings (for control, alarm, warning lights, &c.). Multi-point instruments may have cams arranged to provide on-off control on all points independently. Pneumatic proportional control providing a proportional band adjustable between 2 per cent and 600 per cent or transmitting directly into a three-term controller can also be supplied.

Highway Needs of Great Britain

The Institution of Civil Engineers is organising a conference on the highway needs of Great Britain, which is to be held at the Institution next November, from the 13th to the 15th of that month. The Institution draws attention to the growth of congestion and accidents on the roads and points out that one of the major tasks of the civil engineer in the next decade or two will be to build new highways and to improve existing highways. It is further stated that "it is important to the nation that the problems and considerations involved in the task should be fully understood and discussed by engineers, so that they can play their full part in their solution." The conference is intended as a forum for such discussion, which will be attended not only by engineers "but by others whose responsibilities may place them in a position to influence public opinion and policy on this great question."

The papers which are to be presented at the conference are as follows : "The Basic Requirements for the Roads of Great Britain," by Dr. W. H. Glanville and Dr. R. J. Smeed ; "What Should be the Relative Priority in Great Britain for : (i) the Construction of New Roads and Major By-passes, both as Motorways and All-purpose Roads, and (ii) the Improvement of the Remaining Roads," by Mr. J. Drake ; "The Urban Problem, including Parking, and How it Should be Dealt With," by Mr. R. Nicholas ; "Research in Relation to Highway Needs," by Dr. W. H. Glanville ; "Traffic Engineering and the Need for its Development in Great Britain," by Mr. J. T. Duff ; "The Suitability of the Existing Highway Organisation to Deal with an Expanding Programme of Road Construction," by Mr. S. M. Lovell ; "The Resources Available for Extensive Highway Construction and the Method of Handling a Large Programme," by Mr. H. J. B. Harding ; "Recruitment and Training of Engineers for Highway Engineering," by Professor W. Fisher Cassie, and Messrs. R. A. Kidel and W. K. Laing ; "An Assessment of the Economic Loss to the Country due to Inadequate Highways," by Mr. C. T. Brunner ; and "An Assessment of the Cost of an Adequate Highway System," by Messrs. R. Nicholas and J. H. H. Wilkes. The papers will be available in late October, to those who have registered with the Institution's secretary.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

WOODEN PATTERN EQUIPMENT FOR FOUNDRIES

No. 467 : 1957. Price 5s. The previous edition of this standard prescribed a method of colouring and marking wooden patterns used for ferrous and non-ferrous castings. The new edition has been published at the request of the National Society of Master Pattern Makers, and it includes the same information and coloured diagram, together with a set of provisions dealing generally with the construction of wooden patterns of the following classes :—skeleton patterns; strickle boards; softwood pattern equipment ; softwood equipment with hardwood reinforcement ; hardwood equipment, and hardwood equipment reinforced with metal.

The standard includes clauses specifying the types and conditions of timber to be used and the provision of information by the pattern maker to the foundry.

SOLID DRAWN COPPER ALLOY TUBES FOR HEAT EXCHANGE EQUIPMENT IN THE PETROLEUM INDUSTRY

No. 1464 : 1957. Price 4s. This revised edition of B.S. 1464 specifies requirements for five alloys, whereas the 1948 edition specified only two. The alloys specified and their designating symbols which are to be used in the forthcoming schedule of copper and copper alloy tubes are as follows :—Aluminium brass, CZ 110 ; Admiralty brass, CZ 111 ; 7 per cent aluminium bronze (copper aluminium), CA 102 ; 70/30 brass, CZ 105 ; and 70/30 copper nickel, CN 107.

The publication is divided into two sections, giving "general clauses" and "specific clauses" respectively, and is supplemented by an appendix containing eight half-tone photographs illustrative of grain size, which are reproduced by courtesy of the American Society for Testing Materials.

Durban Harbour and Railway Improvements

BY OUR SOUTH AFRICAN CORRESPONDENT

NEW projects which will cost more than £12,000,000 to complete are being undertaken by the South African Railways in the Durban area, including the harbour. Nearly £2,000,000 will be spent on new station buildings, work has started on a new administrative block to cost £1,000,000, while in the docks a passenger terminal, cargo shed, precooling store and ship repair facilities are under construction. At the Bay Head a new marshalling yard has just been completed while the quadrupling of the Durban–Booth line is well under way.

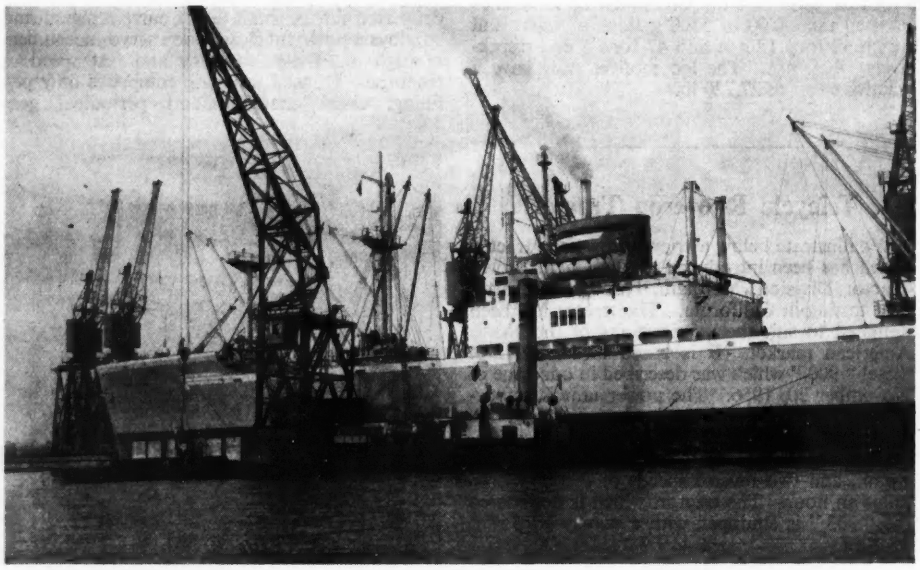
Cargo Shed and Precooling Store.—The latest progress report shows that in connection with harbour improvements, which will cost about £3,206,000, the construction of two sheds at " L " and " M " berths on the T-jetty at an estimated cost of £1,122,250, including the cost of new wharf cranes, will soon be started. The shed at " L " berth will be built at the landward end of the jetty and will consist of a single-storey cargo shed with a floor space of 600ft by 120ft. It will be connected with " M " shed at first-floor level by means of a shipping gallery, which will facilitate the shipping of fruit from both " L " and " M " berths.

The shed at " M " berth will be a three-storey, brick-faced building, to be built on the outer end of the jetty. The ground floor, with a space of 900ft by 160ft, will consist of an airlock and an engine-room with space for cargo stacking. The first floor will be 900ft by 150ft, a quarter of which will accommodate a staff mess, changing rooms, various offices and cargo space. The balance will consist of precooling chambers capable of handling 3000 tons of fruit. This floor has been so designed that the capacity of the precooling chambers can be doubled at a later stage.

Passenger Terminal.—The second floor of the shed at " M " berth will be 800ft by 128ft, part of which will be used for fruit repacking. The rest of the floor will be used for handling passenger traffic and incorporates designs based on the terminal at Southampton. It will be provided with refreshment rooms, customs offices and examination and search rooms, retiring rooms, and offices for shipping companies, the Publicity Department, the Port Captain and administrative staff. The work on this project will be completed in about two years' time.

Ship Repair Facilities.—Ship repair facilities will be moved from the T-jetty to the Bay Head, where 77 acres have been reclaimed. The work on this project will consist of the construction of a 700ft long, double-faced jetty, deepening of the S.A.A.F. basin and approaches to a depth of 28ft below L.W.O.S.T., and construction of a dolphin berth along the south-eastern arm of the basin, at a total estimated cost of £250,000.

Further major works in the harbour area include the replacement of the existing wood and iron sheds at " D " and " E " berths with a single shed of 760ft by 120ft, of the latest steel frame design, with brick panels at an estimated cost of £216,000. At Maydon wharf, the 2000ft long timber-constructed wharves at berths 1, 2, 3 and 4 are being rebuilt with steel sheet piling in units of 500ft, to give a depth of 32ft 6in below L.W.O.S.T., at an estimated cost of £400,000.



Durban's floating crane unloading heavy crates from a ship's hold

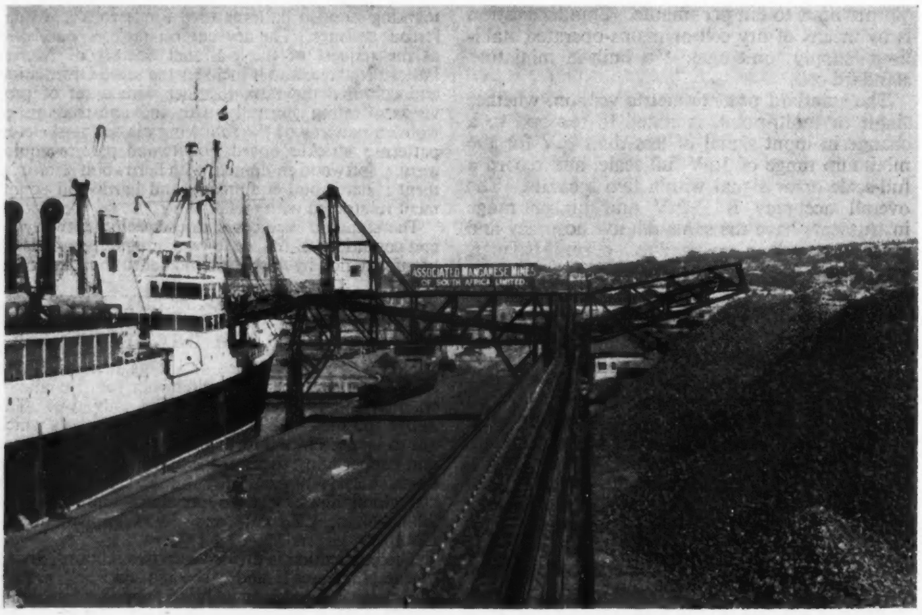
Marshalling Yard.—The recently completed marshalling yard at the Bay Head was built at a cost of £4,250,000 and was placed in service on April 15 this year. The possibility of converting it into a mechanical hump yard is now under consideration. If undertaken, this work will take about eighteen months to two years to complete, but it will mean that part of the yard will be out of commission for this period.

Quadrupling of the Durban–Booth Line.—Owing to the density of traffic on the Rossburgh–Durban double line the need for quadrupling the Durban–Booth section became necessary, and work on this project was started approximately two years ago at an estimated cost of £2,104,750.

The double line from Durban to Rossburgh branches in four directions, along the old double main line to Pinetown, the new double line via Marianhill, the South Coast double line and the Bluff double line. The main line from Durban to Booth passes through the industrial area of Durban, which results in numerous train and engine movements across the main lines. With the quadrupling of this section and the increased train movement it was necessary to provide flyover bridges so that trains may pass over or under the main line. About one-third of this project has been completed.

Administrative Building.—A new administrative block to cost £1,000,000 will be erected in South Street just east of the City Hall. This building has been designed in two blocks. The main block fronting South Street will consist of nine storeys plus a basement, and will have easy access to the block at the rear by means of staircases. The rear block will be four storeys high when this becomes necessary.

Acknowledgment is made to the South African Railways for the photographs accompanying this article.



Loading manganese ore at Durban Harbour

Ferro-Manganese to be made in S.A.

At the annual meeting of the Associated Manganese Mines of South Africa, in June, the formation of a new company—Feralloys, Ltd.—to make ferro-manganese in South Africa, was announced. This new company has been formed with an authorised capital of £1,000,000, of which £1,000,000 will be issued initially. Associated Manganese and other companies have agreed to take up the initial capital.

Associated Manganese will have a substantial interest in Feralloys Ltd., and an agreement has been concluded with that company for the receipt of its total manganese requirements and for the supply of iron ore in the event of Feralloys requiring it for the production of pig iron. Since ferro-manganese sells at a higher price than manganese ore, its manufacture in South Africa will naturally mean more foreign exchange for the Union for that portion of the country's exports shipped as ferro-manganese.

Industrial and Labour Notes

Iron and Steel Plates

The Board of Trade has announced a further suspension of import duty on iron and steel plates. Under the Import Duties (Exemptions) (No. 4) and (No. 6) Orders, 1957, the import duties on a wide range of iron and steel products, including almost all plates, are suspended until March 18, 1958. After consultation with the Iron and Steel Board about the supply position, it is stated, Her Majesty's Government has decided to prolong until September 18, 1958, the suspension of import duty on such plates.

A new order, the Import Duties (Exemptions) (No. 10) Order, 1957 (S.I. No. 1388), has been made and will come into operation on March 19, 1958. The question of further suspension of duty on other iron and steel products after March 18, 1958, is being examined says the Board of Trade, and an announcement will be made in due course in respect of the duties on these other products.

Mechanical Engineering Craft Practice

The City and Guilds of London Institute has announced the publication of a new scheme of examinations in mechanical engineering craft practice, which will provide a qualification of craft proficiency for many candidates who previously have been unable to obtain a nationally awarded certificate. The scheme has been devised mainly for the many students engaged in the industry who receive part-time day technical education, but who cannot achieve the theoretical standard required in the machine shop engineering examinations. Existing machine shop engineering examinations will not be affected.

The syllabuses are based on a four-year course of part-time instruction and candidates for the examinations will be required to have completed the course. The examinations, which will be in two parts, at the end of the second and fourth years, will consist of a practical test to be undertaken during the last term of each course, and a written paper of three hours duration. In addition, it is stated, colleges will set their own examinations in social studies, which are to be introduced for the first time in any scheme prepared by the Institute. Copies of the regulations and syllabuses may be obtained from Gresham College, Basinghall Street, London, E.C.2.

Development in the Steel Industry

The Council of Ironfoundry Associations has announced that it considers that some of the statements on ironfounding made in the Iron and Steel Board's recently published special report entitled "Development in the Iron and Steel Industry" need further explanation. This report was summarised in our issue of July 26, and commented upon in our issue of August 2. The statements referred to are contained in paragraph 211, on pages 75 and 76, of the report.

The Council has issued a statement in which it says that, while the report states that the ironfounding industry is not declining, the phrasing used might convey the opposite impression. The statement then calls attention to the following points. Iron castings production has increased from approximately 2,500,000 tons in 1946 to 3,900,000 tons in 1956. Comparisons based on weight alone can be misleading, as better foundry techniques, casting designs, and metallurgical control have resulted in reducing the weight required for a casting for a specific job. The statement that "this trend may even be accelerated," that is, the trend away from iron castings, is, states the Council, open to doubt, as the statistics used for deducing this trend are based purely on weight. It is implied, says the statement, that the iron casting and steel fabrication are interchangeable according to the prevailing supply position, but this is not so, states the Council, as both forms of construction and both types of material have their specific roles to play. The statement concludes by expressing the hope that the points to which it has drawn attention show that the ironfounding industry is in fact thriving.

Employment and Unemployment

The Ministry of Labour's latest report on the employment situation in Great Britain states that at the end of June the number of people in civil employment was 23,026,000 (15,253,000 men and 7,773,000 women). This was 28,000 more than at the end of May.

In the manufacturing industries the number of people employed at the end of June was 9,137,000, 7000 less than at the end of May, whilst in the basic industries, mining, gas, electricity, water, transport and communication, and agriculture and fishing, the number employed increased by 5000 during June to a total of 3,994,000. Figures for the building and contracting industries remained fairly even, 1,509,000 being employed at the end of June, compared with 1,510,000 at the end of May, although this figure of 1,509,000 at the end of June, 1957, shows that 32,000 less people were employed in these industries than at the end of June, 1956. There was an addition of 1000 to the labour force in the vehicle building industry, making the total at the end of June 1,200,000. In engineering, metal goods and precision instruments the labour force decreased by 3000 during June to 2,774,000, compared with 2,801,000 at the end of June, 1956.

The statement by the Ministry on unemployment says that the number of persons registered as unemployed in Great Britain on July 15 was 244,306, compared with 264,723 registered on June 17. The total number unemployed for more than eight weeks at July 15 was 115,136, 83,588 of this number being men of eighteen years and over. Of the 244,306 unemployed, the statement points out, 38,295 are married women.

Coal Production

Coal production in Great Britain for the first thirty-one weeks of this year was better than during the corresponding period of 1956. Total saleable output to August 3 amounted to 135,705,800 tons, compared with 132,472,100 tons for 1956. Deep-mined coal accounted for 127,661,900 tons of this figure and opencast coal the remaining 8,043,900 tons.

The manpower situation is also better than it was a year ago. The average weekly number on colliery books for 1957, thirty weeks in this case, was 710,300, compared with 704,000 for the corresponding thirty weeks of 1956, though the number of face workers has dropped from a weekly average of 287,000 in 1956 to 285,700 in 1957. Output per manshift has improved this year, both overall and at the face. Absence percentage has been lower so far, the figures being 12·85 for 1957 and 13·03 for 1956, although the voluntary absence percentage has shown an increase from 4·12 in 1956 to 4·84.

The coal consumption figures issued by the Ministry of Power indicate that inland consumption for the first thirty weeks of this year, amounting to 125,413,000 tons, was some 2,000,000 tons less than in the comparable period last year. The amount taken up by export and bunker requirements, 5,038,000 tons, was also lower. Coal imports this year have amounted to 2,020,300 tons, compared with 3,699,700 tons for the corresponding thirty weeks last year.

National Industrial Safety Week

The safety week organised each year by the Royal Society for the Prevention of Accidents has as its slogan this year "Guard Your Hands." Special attention is directed during these safety weeks to the reduction of industrial accidents generally, or to a particular aspect of the problem. Previous campaigns have laid stress on the care of the eyes and the feet. The Society states that in selecting the theme for the 1957 campaign it was influenced by the number of accidents that occur every year to persons engaged in handling goods, and adds that in the last year for which full records are available, 1955, no fewer than 44,613 persons were involved in handling accidents in factories alone. The total of reportable factory accidents for the year was 163,332, for all causes.

The Society states that the campaign will be directed mainly at managements who, during the week, September 30 to October 5, will be asked to do everything possible to encourage their employees to work safely, and, in particular, to guard their hands. Local industrial accident prevention groups will be supporting the campaign and in some instances will be organising special functions in co-operation with local authorities and Chambers of Commerce.

Overseas Trade

The Board of Trade's provisional figures for overseas trade in July show that the value of United Kingdom exports was £281,400,000 and was equal to the monthly average of the first half-year, and £5,500,000 more than in June. Imports in July were 3 per cent above the monthly average in the first half-year, and amounted to £359,600,000, showing an increase of £36,000,000 over the low June figure. The value of re-exports in July was £9,400,000, 19 per cent less than the monthly average in the first half-year. The excess of imports over exports and re-exports in July was £68,800,000, an increase of £31,000,000 on the June figure, and £12,000,000 more than the monthly average in the first half-year.

Exports to North America from the United Kingdom in July amounted to £38,800,000, 9½ per cent more than the monthly average for the first half-year, and £4,500,000 more than in June. The Board of Trade adds that silver bullion repayments to the U.S.A. from January to April, 1957, are excluded from this comparison. The value of exports to the United States in July was nearly £1,500,000 more than in June and amounted to £21,100,000 and, excluding silver bullion repayments, was 7½ per cent more than the monthly average in the first half-year. United Kingdom exports to Canada in July amounted to £17,700,000, 12 per cent more than the monthly average in the first half-year and £3,000,000 more than in June.

Austrian Pumped Storage Scheme

The Lünersee pumped storage scheme in Western Austria will have six 45MW pumping sets, operating with a head of nearly 1000m. Three sets are expected to be operating in October. The significance of the scheme in relation to the series of peak load hydro-electric stations in the upper part of the River Ill catchment is explained, and the Lünersee scheme itself is described.

AUSTRIAN hydro-electric design and practice has been reviewed recently in these columns in the descriptions of the Ybbs-Persenbeug and Glockner-Kaprun schemes.* Those two articles gave a reasonably typical cross-section of contemporary trends in that country, but there is one other aspect of recent work there which was touched on only to a limited extent. The central geographical position of Austria and the surplus of potential hydro-electric energy have encouraged the development of exports of power. The schemes described in this article have been developed, over a number of years, primarily for that purpose; furthermore, they export to one grid system in West Germany and they supply peak load power. This rather specialised function has influenced the design of the schemes, and has led to some interesting and large-scale developments in pumped storage. Recent developments in this country's electricity supply system and, in particular, the advent of nuclear power, have emphasised the advantages of pumped storage for peak load generation, so recent Austrian achievements in this field may prove of particular interest. They may also be compared with a German pumped storage scheme of similar capacity but of rather different conception—the Geesthacht scheme—described in this journal on April 5 last.

The schemes to which we refer utilise the upper catchment of the Ill River in Vorarlberg, where the Ill flows down the Montafon Valley. The company responsible for development here is the Illwerke A.G.; this firm has its headquarters in Bregenz, and has in the past looked largely to German capital for financing its new works. The power which it produces is transmitted principally to the grid system of the Rheinisch Westfalisches Elektrizitatswerk A.G., of Essen, and the Energie-Versorgung Schwaben A.G., of Stuttgart-Biberach. However, some power is consumed in Austria in Vorarlberg itself and in the Tyrol, and the main substation of the Illwerke schemes at Bürs has been connected with the Austrian grid system since 1945.

By comparison with the other Austrian schemes we have mentioned, the River Ill schemes are less impressive in size and interest, particularly from the civil engineering point of view. But, by meeting the peaks, and by frequency regulation, on the neighbouring German grid, they have an importance greater than the figures for their output would suggest. Several new power stations burning brown coal are being constructed in Germany to serve this system, and corresponding new works are in progress in the Ill valley, so that the installations there will still maintain their special function. The principal element of the new works is a pumped storage power station of large capacity, but before describing it, a general outline of the River Ill schemes as a whole, and of their operation, is necessary. The new station, known as Lünersee power station, is now at an advanced stage of construction, and three sets are expected to be in operation in October.

THE RIVER ILL POWER STATIONS

The works in operation or under construction along the upper Ill afford fairly complete utilisation of that catchment. The various reservoirs and power stations are shown in Figs. 1 and 2, and the principal data for them are listed in Table I.

At present the largest reservoir is at Silvretta, which is the head of the system. It feeds the upper Vermunt power station. The power station of this upper stage went into operation in 1943 and the dam was completed in 1948. The main stage below it, culminating in the Vermunt power station, has been in operation since 1931, although the principal turbines, which are Pelton machines, have been re-modelled since the war, with two jets instead of one, and the aqueduct system from the Tyrol, consisting mainly of tunnels and extending for about 30km, has been added. The additional catchment area thus utilised is about 115 square kilometres, and as a result the total production of the group of schemes has increased by more than 50 per cent.

The upper Vermunt stage includes a gravity dam 80m in height which, with two subsidiary dams, forms the Silvretta reservoir. The catchment supplying this reservoir is 45 square kilometres in extent, including 9 square kilometres captured by a tunnel; of this area 13 square kilometres is glaciated. A steel pipeline extends for a distance of about 3km from the dam to the power station. It is noteworthy for the fact that there is no surge shaft; the two Francis turbines in the upper Vermunt station thus operate with relief valves and with governing which permits a substantial increase in turbine speed, should the load on the machine be shed. This station is controlled remotely from Vermunt.

There is a small reservoir at the tail water of the Vermunt station and a long free-flow tunnel extends from it to Latschau, a distance of about 20km. At Latschau there is a reservoir forming a head pond, and giving capacity for pumped storage for the Rodund station. This reservoir is formed in the hillside by extensive embankments and is lined with concrete with a bitumen seal; it is 18m in depth and holds nearly a million cubic metres, with a top water level of 992m.

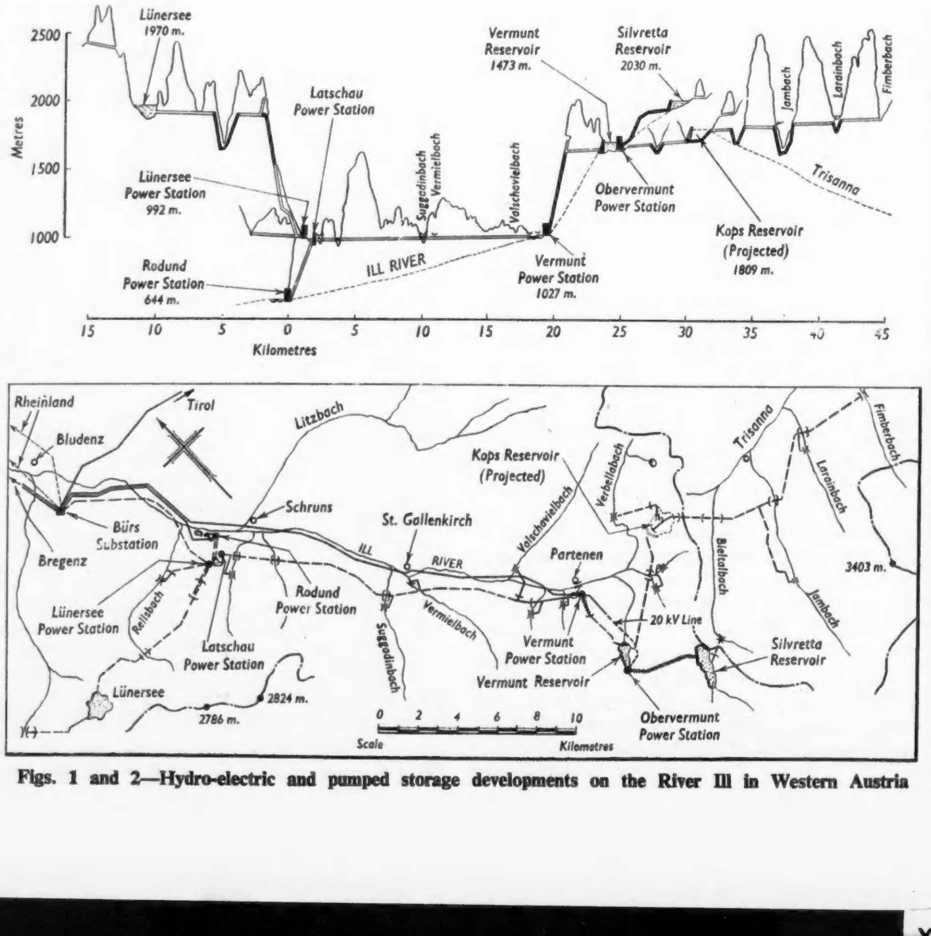
There is a head between the end of the free-flow tunnel and this reservoir. Hence, the Latschau power station has been built in a reinforced-concrete tower-like structure standing on the reservoir bottom. Two Kaplan turbine generator sets are installed in it, to utilise the energy thus available.

The penstock to Rodund power station leads

TABLE I—*Power Stations in Operation on the River Ill*

Power station	Average net head, metres	Rated flow, cumecs	Useful storage capacity of associated reservoir, cu. m × 10^6	Capacity available at Bürs substation, MW	Average annual production, kWh × 10^6		
					Summer	Winter	Total
Obervermunt	257	14	38·6	29	19	26	45
Vermunt	665	26	5·4	140	301	123	424
Latschau	11 to 28	40	0·1	8	17	6	23
Rodund	328	60	1·0	170	328	145	473
Total capacity available at Bürs substation	—	—	—	347	—	—	—
Average annual production of existing installations	—	—	—	—	665	300	965

Note:
(1) The aqueduct system from the Tyrol is at present equivalent to about 390 million kWh. Two further streams have still to be diverted.
(2) Rodund station has a pump set of 40MW. The total output given for Rodund includes 40,000,000kWh of pumped storage.


Lünersee
1970 m.
2500
2000
1500
1000
Metres
Latschau
Power Station
Lünersee
Power Station
992 m.
Rodund
Power Station
644 m.
Suggadinbach
Vermielbach
Valschavielbach
ILL RIVER
Vermunt
Reservoir
1473 m.
Silvretta
Reservoir
2030 m.
Vermunt
Power Station
1027 m.
Obervermunt
Power Station
Kops Reservoir
(Projected)
1809 m.
Jambach
Larainbach
Fimberbach
Trisanna
15
10
5
0
5
10
15
20
25
30
35
40
45
Kilometres
Rheinland
Tirol
Bludenz
Litzbach
Schruns
Bürs
Substation
Bregenz
Lünersee
Power Station
Rellsbach
Latschau
Power Station
Rodund
Power Station
Lünersee
2786 m.
2824 m.
St. Gallenkirch
ILL
RIVER
Suggadinbach
Vermielbach
Kops Reservoir
(Projected)
Valschavielbach
Verbellabach
Partenen
Vermunt
Power Station
Vermunt Reservoir
20 kV Line
Obervermunt
Power Station
Trisanna
Bieltalbach
Larainbach
Jambach
Fimberbach
3403 m.
Silvretta
Reservoir
0
2
4
6
8
10
Scale
Kilometres

Figs. 1 and 2—Hydro-electric and pumped storage developments on the River Ill in Western Austria

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* Ybbs-Persenbeug, THE ENGINEER, July 20, 1956; Glockner-Kaprun, THE ENGINEER, September 14, 21 and 28, 1956.

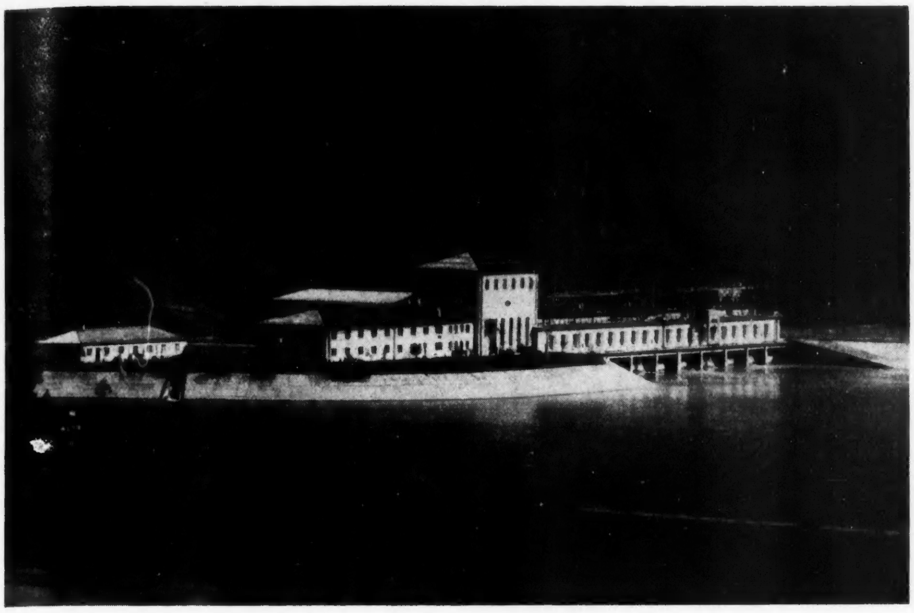


Fig. 3—Rodund power station. The tail reservoir, which serves the pump set, is in the foreground. The machine hall is to the right of the building, with the substation on its roof

from the reservoir; it has a length of 850m. Rodund station is illustrated in Fig. 3. The main plant installed consists of four horizontal-shaft Francis turbine generating sets; two of these sets are designed for operation with pumps, but only one pump has so far been installed. The maximum gross head on the turbines is almost 350m, which at the time of installation of the first sets (1943), was the highest in the world for a Francis turbine. It is only quite recently that Francis machines for higher heads have been constructed.

The station has a tail reservoir, and the machine hall is set very low, so as to provide the slight head needed on the inlet side when pumping. It is also noteworthy for the horizontal-shaft layout of the turbines, which was adopted because two of the sets were to have pumps. The pump installed at present is a two-stage centrifugal machine. A small Pelton turbine is built onto the pump shaft, and is used to run the pump up to speed (with the pump chamber emptied with compressed air) before it is coupled to the generator/motor of the main set. The pump will delivery 9·5 cumecs, corresponding to 40MW and 343m head.

Latschau station is controlled from Rodund, where control of the division of load between the various stations of the scheme is also effected. All the power generated goes on a 110kV line to the substation at Bürs.

Peak Load Operation

It will be seen that a layout rather more flexible than usual has been chosen for the three stages of the River Ill schemes because of their peak load duties. Thus, there is a reservoir above and below each power station. In particular, the Latschau reservoir gives greater flexibility in the operation of Rodund station. The unusual occurrence of a low-head station with Kaplan turbines, as an intermediate stage of an Alpine series of schemes, has also resulted from that arrangement.

The Rodund pump was installed in 1952 and was the first large pumped storage set in Austria. It has been operated for about 1500 hours annually since that time, principally at night, but also at times of light load or when a fault occurred in the network, to help in maintaining the frequency. Fig. 4 shows typical load curves with the contribution made by the pump. The pump set operates on a daily basis; pumping periods are shown in Fig. 4 as are also the periods during which the Illwerke's installations are holding the frequency of the network. Such operation requires rapid changeover from turbine to pump, which can be achieved in four minutes with the Rodund set. The overall efficiency of the pumped storage energy is 65 per cent, which is economical under the conditions prevailing, in spite of the long distance over which the power is transmitted. The set adds 40,000,000kWh of peak load energy per annum. Energy for operation of the pump comes from the German brown coal stations.

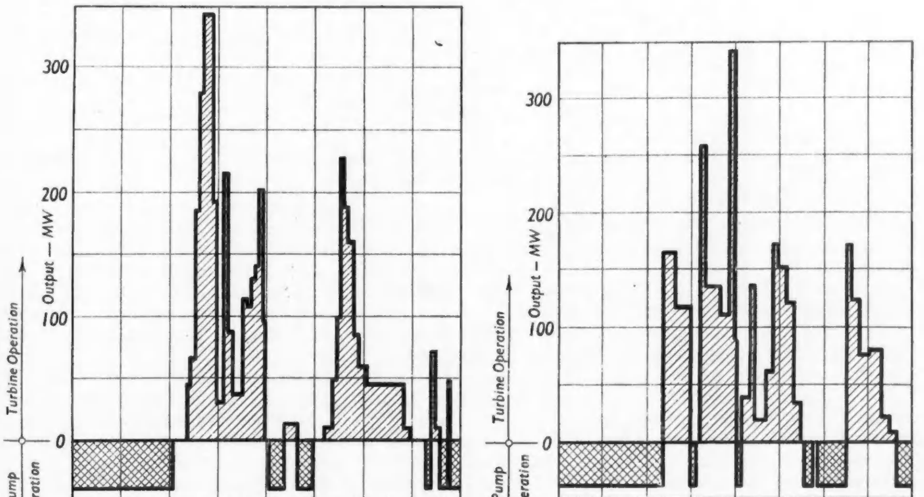


Fig. 4—Typical load diagrams of the Illwerke's group of schemes as operated at present, with a single storage pump at Rodund power station

New Works

The Lünersee scheme will make a very appreciable addition to the Illwerke's peak load capabilities. Construction is being kept in phase with new generating plant in Germany, and with the addition of 380kV high-tension transmission lines from the Bürs substation. Apart from the Lünersee scheme, however, the company plans to build a seasonal reservoir on the Tyrol aqueduct system (shown in Figs. 1 and 2), which will regulate that section of the scheme and increase the proportion of power available in winter by providing storage to the extent of 44 million cubic metres. Furthermore, six stages of development are envisaged on the River Ill, below Rodund. These six stages will effectively complete the utilisation of the catchment, but their operation will be controlled by the storage works above them, one of the principle elements of which will be the Lünersee scheme. The first stage below Rodund has already been designed, and will comprise a 30MW power station.

The Lunersee Scheme

Pumped storage on the scale of the Lünersee project is still unusual in hydro-electric construction, although the indications are that such schemes will become more commonplace in the future. The Lünersee is a natural lake, 1940m above sea level, situated in the Ratikon very close to the Swiss border, as Fig. 1 shows. It drains only a small catchment, 8·8 square kilometres in extent. The lake was first considered as a hydro-electric reservoir in the early 1920s, when it was proposed to divert adjoining streams into it. The lake is formed by a natural ridge of rock, which was treated by grouting to render it impermeable at the time that this early scheme was considered. However, no further works were carried out at that time, and the scheme was abandoned.

The present scheme envisages only a modest increase of 3·2 square kilometres in the catchment draining into the lake (Fig. 1 shows the various works referred to here, and the principal figures are listed in Table II) by constructing a tunnel aqueduct from the Brander glacier. The storage capacity available in the lake can be increased by building a dam of modest size along the top of the natural ridge. Thus, the grouting works carried out some thirty years ago are now being made use of. The intake beside the dam will lead through an extensive aqueduct system, comprising a pressure tunnel, with an inverted siphon at a valley crossing, a surge shaft, steel penstocks, and finally a pressure shaft, terminating in the Lünersee pumping station, which is

Table II—*Principal Data for the Lünersee Scheme*

Machine data :	
Ultimate number of sets … … … … …	6
Installed capacity of each set :	
Turbine operation (output) … … … …	44·8MW
Pump operation (demand) … … … …	50·4MW
Total installed capacity available at Bürs substation (6 units) :	
Turbine operation (output) … … … …	217MW
Pump operation (demand) … … … …	253MW
Operating speed of sets … … … … …	750 r.p.m.
Water and power economy :	
Mean annual flow from the augmented catchment area draining into Lünersee … … …	17,000,000 cubic metres
Additional annual inflow by pumping needed to fill the reservoir … … … … … …	59,000,000 cubic metres
Corresponding power demand for pumping …	198kWh × 10^6
Annual winter peak power production utilising the natural annual flow and the pumped storage … … … … … … … …	152kWh × 10^6
Additional winter peak load power produced at Rodund power station due to the operation of the Lünersee plant … … … …	57kWh × 10^6
Additional peak power production at Lünersee power station due to day-night pumped storage (superimposed) :	
During summer … … … … … …	80kWh × 10^6
During winter … … … … … … …	121kWh × 10^6
Average gross output due to Lünersee scheme (production in Lünersee power station and additional production in Rodund power station) … … … … … … … …	410kWh × 10^6

now under construction beside the Latschau reservoir.

The dam at the Lünersee will be a concrete gravity structure with a maximum height of 30m and a length of 325m. The useful storage in the lake will be increased from 40,000,000 to 76,000,000 cubic metres by this structure, the augmented storage being sufficient for peak load generation during about five hours daily in the winter six months, which is all the storage required. Topographical conditions would also have limited the construction of a larger dam, we understand.

The tunnel leading from the dam is a pressure tunnel, lined with concrete. The valley crossing consists of two inclined pressure shafts, analogous to the pressure shaft constructed for an underground power station, which connect with short horizontal tunnels. Where these tunnels break out into the open, a steel pipe completes the crossing.

At the end of the tunnel there are a surge shaft and a valve house. The surge shaft arrangement consists of a lower horizontal chamber, connected at one end with the tunnel and at the other with the surge shaft itself; at the top of the shaft, horizontal tunnels form radial expansion chambers.

The drop of almost 1000m down to the pumping station is traversed by a penstock for half the distance, and then by a pressure shaft. Rock conditions were unfavourable for the construction of a pressure shaft in the upper part of the mountainside, and so this compromise solution was found to be the best. The penstock is held at twelve anchor blocks by steel bands. Expansion joints are situated between the anchor blocks.

The pressure shaft is steel lined, the steel lining being welded and backed with prepacked concrete. Welding was tested using radioactive isotopes, as is now customary on such work. The lining pipes were placed from the top of the shaft. Pairs of 33ft pipes were welded together in the open, and then the final joints, between 66ft lengths, were made *in situ*. An interesting rail-mounted twin carriage was used to place the pipes in position. The pipe was supported at each end by one of the carriages, and when it was in position the lower carriage, supported from the last pipe already in position and by the upper carriage, retracted itself through the centre of the pipe.

The pressure shaft is constructed deep inside the rock at its lower end, to give adequate cover to resist the high pressure of the 1000m head. A horizontal steel-lined tunnel leads from it to the Lünersee station. In spite of the shaft layout, it was not considered advantageous to place the Lünersee station underground. The station has a rather unusual layout, due to the great depth of the pump sets, the reason for which is explained in the next section of this article.

From the constructional point of view, the power station has provided no outstanding problems. However, it involves extensive reinforced and prestressed concrete work. The main sets are accommodated in pairs, in massive box-like reinforced concrete constructions, each of the boxes being structurally independent and extending down to good rock. An additional building will house three subsidiary pumps, whose function is explained below. The superstructure of the station is in reinforced concrete. Speed of construction was important here, and the main column, which will carry the crane beams, were built by the vacuum process.

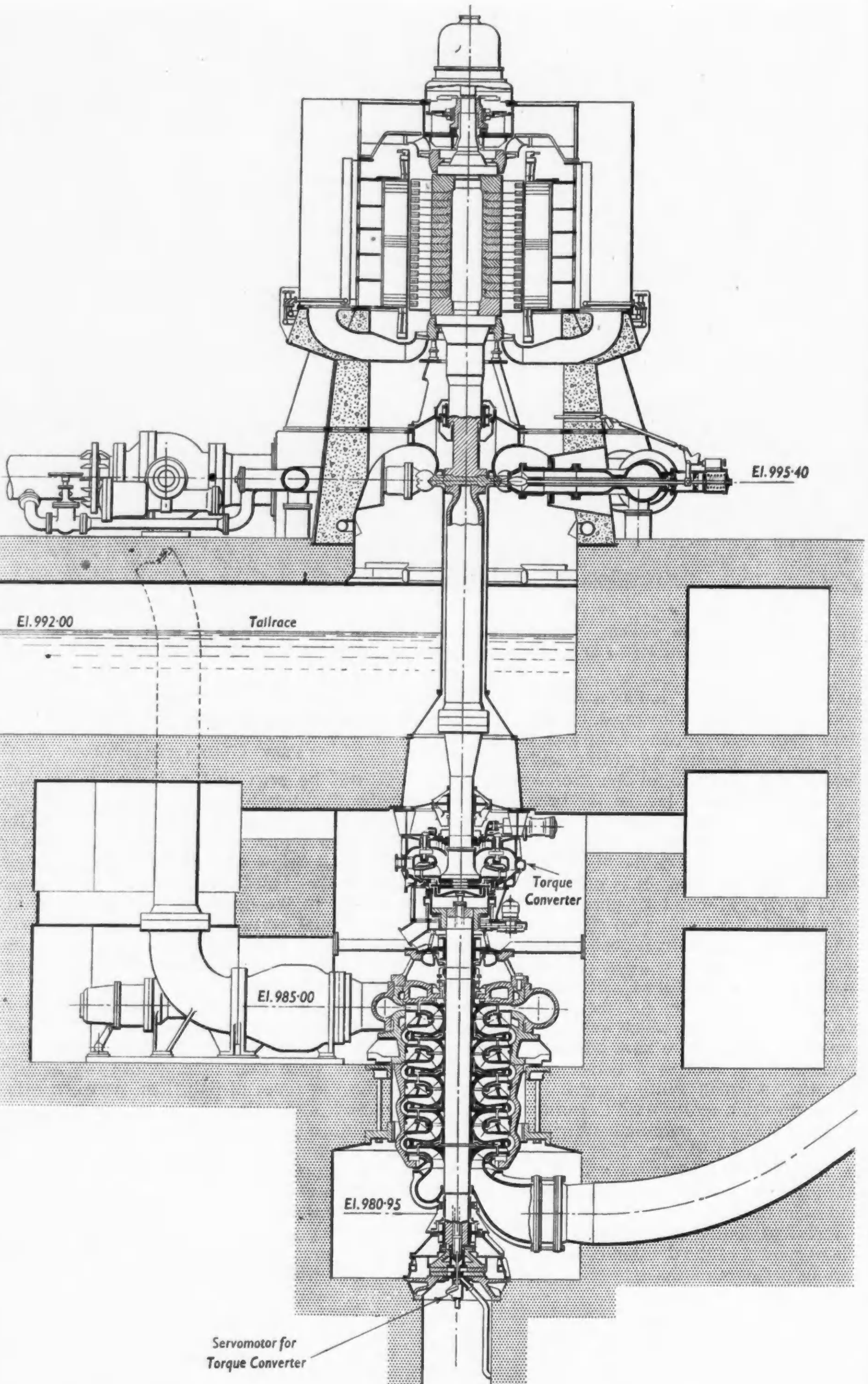


Fig. 5—Main generating and pumping set for Lunersee power station, with torque converter and five-stage centrifugal pump

LUNERSEE POWER AND PUMPING STATION

A cross-section through one of the main sets at Lünersee is shown in Fig. 5. The main plant will consist of six such sets (five sets are being installed in the first stage), each having a vertical shaft layout with a five-stage centrifugal pump, above that a hydraulic coupling, then a four-jet Pelton wheel, and at the top of the shaft the generator/motor. The pump intake leads from a forebay built into the end of the free-flow tunnel from Vermunt; so there are also three subsidiary pumps which will be used to keep the main pump intake filled when the flow down the tunnel is insufficient, and the Latschau reservoir is drawn down to supplement it. Such operation will also be necessary when the second pump is installed at Rodund, and some water will then be pumped up both stages.

In designing these sets a gradual transition, as the load decreased from the positive load of turbine operation to negative load of pump operation, was needed together with ability to change rapidly from pump to turbine and vice versa. It was considered impracticable, with the greatly increased head and size of the sets, to use the same method of control as at Rodund, and in particular emptying five stage pumps with compressed air was not considered feasible. Hence the hydraulic coupling was designed. Although such devices are common in automobile and marine engineering, none of such size as those at the Lünersee station have been built elsewhere, as far as we know. In other pumped storage schemes hydraulic couplings have been considered too cumbersome (they add appreciably to the overall size of the set) and expensive, but the special conditions at Lünersee justified their use. The vertical shaft layout was required due to the high surge pressures expected from the pumps, which therefore had to be situated very low, and because the turbine tailrace at the top water level of Latschau reservoir, had to be accommodated.

The load curves and overall operation of the new station in the network are illustrated graphically. Fig 6 shows a typical load curve for a winter day, as it is foreseen with the Lünersee plant in operation, and Fig. 8 shows a typical year's operation of the Illwerke's scheme after the completion of the Lünersee station.

Operation of the Lünersee station will be based on (*a*) seasonal pumping, to fill Lünersee reservoir during the summer. This is sufficient to meet a winter peak lasting for about five hours a day throughout the winter; (*b*) daily pumping superimposed on the seasonal. This allows, in addition, a peak load of about two hours daily to be met during the summer and three hours during the winter by pumping at night for generation the following day.

How this dual operation will be achieved in practice is illustrated in Figs. 6 and 8 and in Table III, which lists the energy production, and consumption in pumping, of the group of schemes. By meeting peaks in summer and winter the schemes provide a range of 900MW (i.e. −330MW pumping to +570MW generating) for frequency regulation of the network. The necessity for rapid control of load changing will be apparent from a study of Fig. 6. For a period of less than half an hour at 9 a.m. there is a drop in load, and the pumps are operated for that brief period; similarly at midday for about an hour. There is further advantage in the Lünersee scheme in that most of the water is pumped up the Lünersee stage only, but generates through two stages, Lünersee and Rodund. The second pump at Rodund will serve mainly to make up the flow to the Lünersee pumps by replenishing Latschau reservoir, when the upper stage tunnel is not at sufficient flow.

TABLE III—*Hydro-Electric and Pumped Storage Energy for the Upper Ill and Lünersee Schemes*

Generation	Energy in kWh × 10^6		
	Summer	Winter	Total
Natural, run-of-river hydro-electric output	833	139	972
Change in energy distribution due to seasonal storage in reservoirs	−168	+168	—
Change in energy distribution at Rodund due to pumped storage at Lünersee	−44	+44	—
Additional energy due to daily pumping at Rodund	—	40	40
Additional energy due to seasonal pumping at Lünersee	—	118	118
Additional energy due to daily pumping at Lünersee	80	121	201
Total production of energy...	701	630	1331
Consumption			
Energy needed for seasonal pumping at Lünersee	198	—	198
Energy needed for daily pumping at Lünersee	135	203	338
Energy needed for daily pumping at Rodund	—	64	64
Total energy consumption ...	333	267	600

PUMP DATA

The Lünersee pumps (Figs. 5, 7 and 9) are remarkable for their large delivery head (about 1000m), which is the highest for which such large units have been built so far. We are informed that the assembling and dismantling of such units was a problem which could best be solved with the vertical arrangement of a multi-stage pump, which also reduced the cost of the buildings. The upper casing is constructed for a test pressure of 190 atmospheres, the lower casing for 115 atmospheres. The guaranteed data for the pump illustrated under test in Fig. 9 are :—

Man. head, metres ...	1,005 ...	971 ...	960 ...	895
Quantity, l/s	3,420 ...	3,730 ...	3,800 ...	4,250
Speed, r.p.m.	750 ...	750 ...	750 ...	750
Efficiency, per cent ...	86·5 ...	87 ...	87 ...	86
Power input, b.h.p. ...	53,000 ...	55,500 ...	55,800 ...	59,000

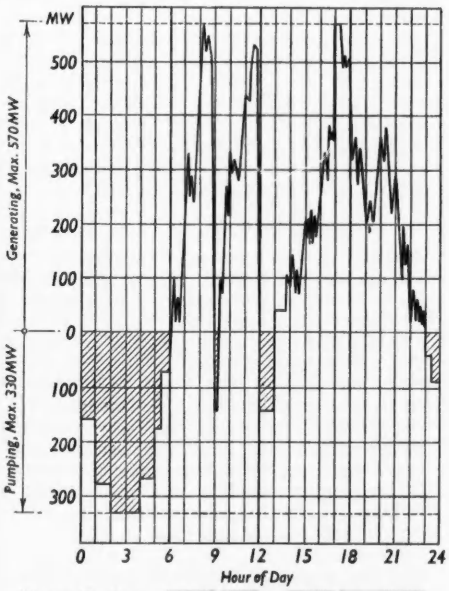


Fig. 6—Typical load diagram, as foreseen for a winter day, with the Lunersee scheme in operation, together with the existing installations on the River Ill

It has been stipulated that the sets must be able to run at a speed of 780 r.p.m. with a frequency of 52 c/s, when the maximum power required by the pump may be 70,000 b.h.p. Performance figures for the Pelton turbines of the main sets, operating at 750 r.p.m. are as follows: net head 900–970m; flow 5·23–5·42 cumecs; power 56,400–62,800 h.p.

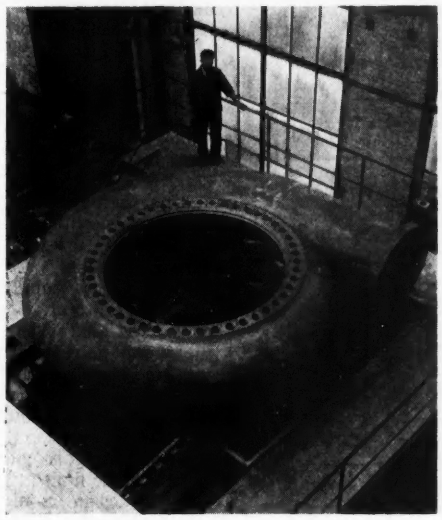


Fig. 7—Pump casing for assembly at delivery end of five-stage pump

THE TORQUE CONVERTER

A change of mode from generating at full power to pumping at full power or vice versa can be effected in eighty seconds. This short interval is necessary for the reasons already explained. It is not easy to design a set to operate in this way; the torque converter solves the problem with a nicety of engineering design worthy of more detailed description. Fig. 11 shows the torque converter diagrammatically and parts of the turbine and pump shafts. The essential elements are the hydraulic converter and a mechanical coupling between the two shafts.

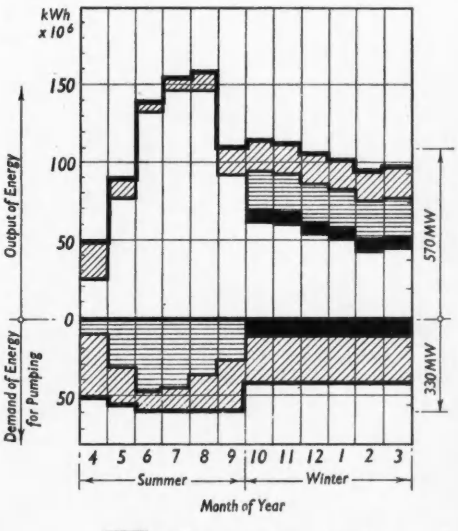


Fig. 8—Annual operation envisaged for the Illwerke installations, when the Lunersee scheme is completed

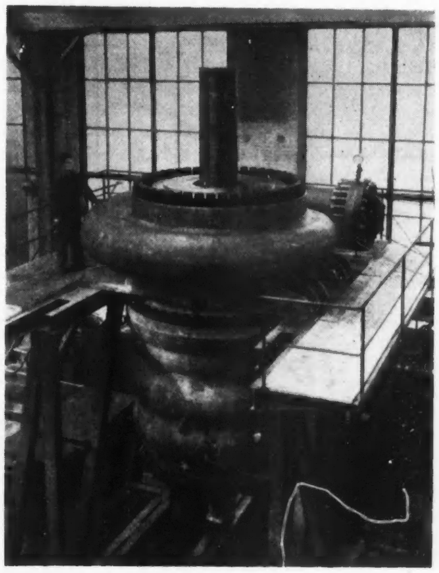


Fig. 9—Five-stage centrifugal pump under test at maker's works. The pump is shown erected for pressure tests, and the suction cover at the lower end has not been fixed

The hydraulic torque converter consists of an impeller solidly coupled to the turbine shaft, a runner similarly coupled to the pump shaft, and two sets of guide vanes, one set of fixed vanes being positioned round the periphery of the hydraulic chamber of the machine, outside the runner and impeller, and the second set, which can be adjusted by servo-motors and linkage, being positioned above the impeller. Considering the case where the pump is to be started, water is admitted to the converter from the pump intake, and the adjustable guide vanes are opened. Thus the converter's impeller drives its opposing runner and the pump shaft is gradually accelerated from rest to a speed which can be slightly above the synchronous speed of the set.

At this stage a rigid mechanical coupling is made between the two shafts. An externally-toothed ring is built on to the turbine shaft, and a similar but internally-toothed ring on the pump shaft. There is also an intermediate ring toothed externally and internally, and this ring is engaged

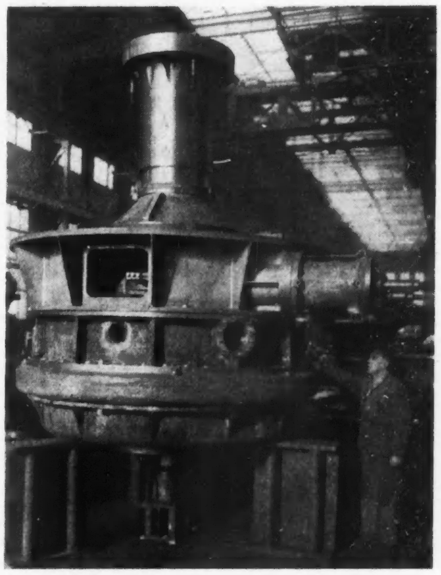


Fig. 10—Exterior construction of torque converter for main sets

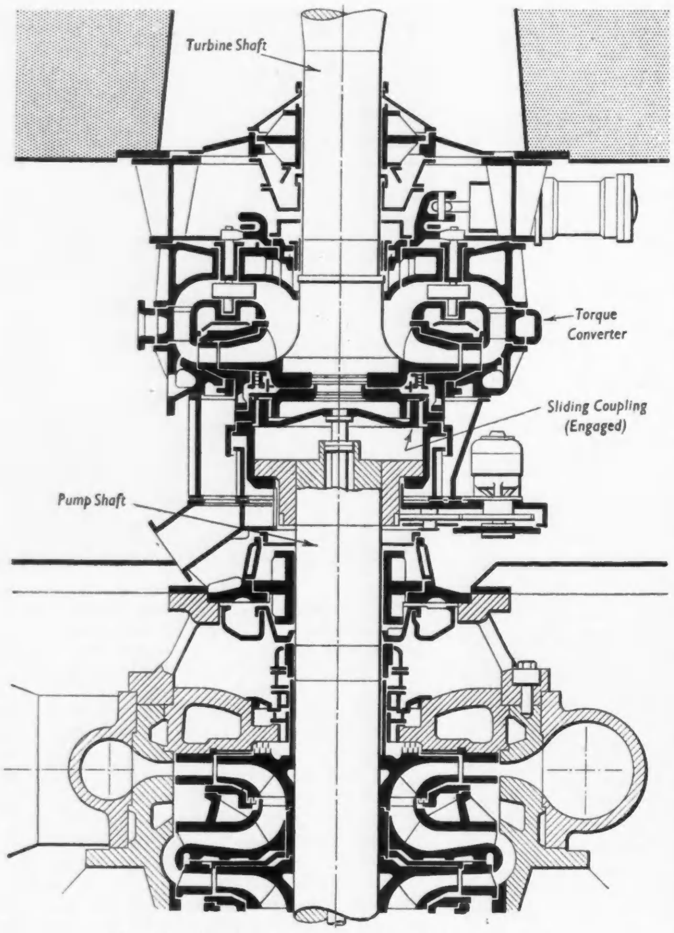


Fig. 11—Torque converter for main sets at Lunersee

between the rings of the turbine and pump shafts by a hydraulic cylinder, to make the rigid coupling. This sliding coupling is shown in the engaged position in the diagram. The servo-motor which controls it is situated below the thrust bearing at the foot of the pump shaft, its position being indicated on the drawing of the main set, Fig. 5. As soon as the mechanical link is made, the converter is emptied of water and the adjustable guide vanes are closed, so as to keep windage losses to a minimum. Until this stage is reached and the penstock pressure is built up the pump delivers against the closed delivery valve. The torque converter has to transmit power during that time at a rate estimated to be 32,000 h.p.

The operation of coupling the pump and turbine shaft is accelerated by bleeding-off water after it has passed through the first stage of the pump, and leading it to the converter chamber. Some pressure quickly builds up at this point, and so the converter is filled more quickly. The rigid coupling is considered to be an important element in the safety and economy of the device. Should there be a power failure with the pump on load, the inertia of the pump alone would be insufficient to prevent it from decelerating very rapidly, and hence inducing unacceptable negative and positive pressure surges in the pipeline. With the whole set coupled together, however, it is considered that even if the pump valve failed the time elapsing before the flow in the penstock changed direction would be sufficient to keep the pressure variations within reasonable limits. In such a design a high efficiency is not essential in the hydraulic transmission, and so clearances can be greater, and consequently a special cooling system dispensed with, and windage losses reduced.

The photograph reproduced in Fig. 10 shows the exterior of the torque converter and gives an idea of its size and construction. The lower part of the turbine shaft is shown above it, and on the right the two servo-motors for the guide vanes can be seen. The hydraulic system for these servo-motors embodies control valves, oil pumps and an oil reservoir and accumulator built as a unit.

Operation of the main set may involve the following modes: rapid starting for pumping from rest; changing from operation with the turbine on load to the pump on load or vice versa; operation of the generator/motor as a synchronous condenser, for phase correction. Automatic control gear covering all these cases, and changes between any of them, is therefore installed. When the pump is to be uncoupled it is not possible to bring the pump shaft to a slightly higher speed than the synchronous speed, as just described for the coupling operation. Therefore the torque converter is filled with water and the pressure in it gradually builds up, thus reducing the load on the rigid coupling. When the latter is unloaded the toothed ring is pulled out by its servo-motor, as the first stage in the stopping sequence.

The torque converters and their control gear for the five main sets at Lünersee were designed and made by J. M. Voith G.m.b.H., of Heidenheim, Germany. In addition, that firm was the supplier of all the hydraulic machines for two of the main sets. Escher-Wyss A.G., of Ravensburg, was the manufacturer for three further turbines and two pumps, and the pump for the fifth set was made by Sulzer Bros., Ltd. This last pump is illustrated under test at the maker's works in Fig. 9, as noted earlier in this article.

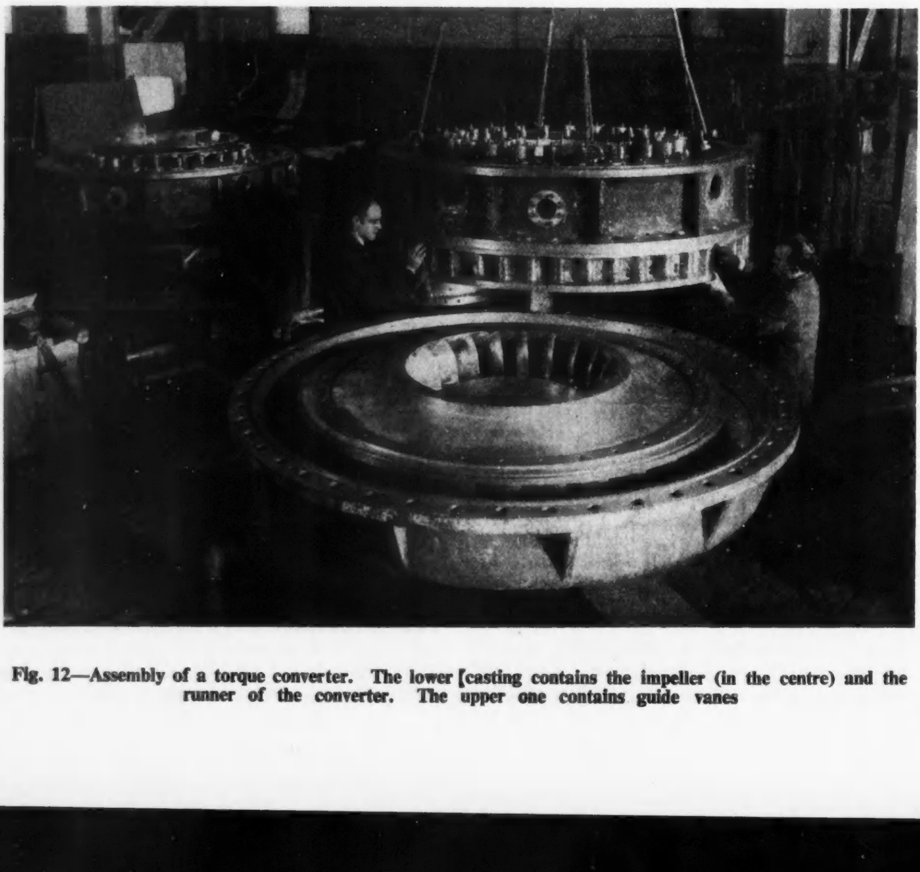


Fig. 12—Assembly of a torque converter. The lower casting contains the impeller (in the centre) and the runner of the converter. The upper one contains guide vanes

Second World Congress for the Prevention of Accidents in Industry

The Second World Congress for the Prevention of Industrial Accidents will be held in Brussels from May 19–24, 1958. As will be recalled, the first congress took place in Rome during the period April 2–6, 1955, under the auspices of E.N.P.I. (Ente Nazionale per la Prevenzione degli Infortuni). The second congress will have the object of continuing and deepening the collaboration of the various official and private organisations concerned. It is being organised on the initiative of the Association des Industriels de Belgique (A.I.B.) and the Association Nationale pour la Prevention des Accidents de Travail (A.N.P.A.T.), with the co-operation of the Netherlands and Luxembourg. The general theme is to be "collaboration in the service of prevention," subsidiary themes will be: the part played by governments (reporter: German Federal Republic), by the employers (reporter: Belgium), by the workers (reporter: Sweden), by the social security institutions and public and semi-public organisations (reporter: A.I.S.S.), by private institutions (reporter: Netherlands), and the contribution of industrial medicine (reporter: France).

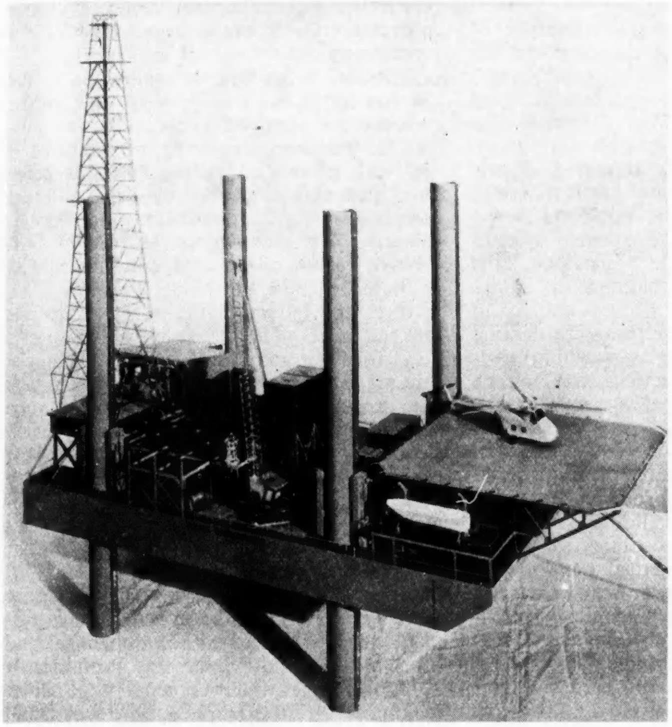
International collaboration will be covered by Asian reports on technical assistance in matters of safety, and by the I.L.O. report on the 1955 Congress. Accident statistics will be discussed on the basis of the classification of accidents (Italian reporter) and the presentation and analysis of the causes of accidents from the point of view of prevention (British reporter); lastly, there is to be a United States report on the safety training of foremen. Those interested are asked to write to Monsieur Georges de Rees, I.C.M., A.I.Br., General Secretary of the Congress, c/o A.I.B., 27–29, Avenue André Drouart, Auderghem-Bruxelles, Belgium.

Oil Search Under the North Sea

During the next few weeks the survey vessel "Gauss" of the German Hydrographical Institute at Hamburg is to begin an investigation of the deeper strata under the North Sea with a view to determining the presence of oil deposits. It is considered that inland oil deposits, in particular the fields "Etzel" and "Elsfleth" and the large oilfield "Heide" in Schleswig-Holstein, which extend to the coast, are likely to continue further under the sea bed. The seismic measurements which will be carried out in the open sea will be supplemented by similar tests and by drillings in the foreshore regions and in the shallow stretches of sea near the coast. The whole research programme, it is estimated, will take five years, partly because the "Gauss" will not be available during the whole of the time. The preparatory work is in the hands of the Hydrographical Institute, the prospecting office in Hanover, and the Association for Practical Prospecting.

Mobile Drilling Barge

A mobile drilling barge, which is the first of its kind to be built in Europe, was launched at Audorf on the Kiel Canal on April 11. The barge was built by Gutehoffnungshütte Sterkrade Aktiengesellschaft of Sterkrade-Oberhausen, German Federal Republic, on behalf of Abu Dhabi Marine Areas, Ltd. This company, which operates in the Persian Gulf, is jointly owned, two-thirds by the British Petroleum Company, Ltd., and one-third by Compagnie Française des Petroles.



Model of 4000-ton drilling barge "Adma Enterprise." At the proposed well site, its four "legs" will be sunk to the sea bed by means of hydraulic jacks

The barge was designed by the DeLong Corporation of New York, in conjunction with Abu Dhabi Marine Areas, Ltd., for operating in water up to 80ft deep. It is approximately 200ft long by 100ft wide and has a depth of 15ft. It has four retractable legs each 10ft in diameter by 165ft long, on which it is elevated or lowered as required by eight hydraulic jacks The weight of the barge in the condition in which it will be towed to the Persian Gulf will be approximately 4200 tons and when floating its draught will be approximately 10ft 6in.

A "National 130" drilling unit complete with all the necessary drive gear, pipe racks, drill pipe, &c., capable of drilling a hole up to 15,000ft deep, will be installed. This unit is powered by four 400 h.p. "Paxman" engines. The 140ft high derrick is mounted on a base 30ft square and is capable of a maximum pull of 500 tons.

For the storage of the various chemical materials which are required in the drilling operations, three large hoppers have been installed. These hoppers are capable of handling 140 tons of cement, 125 tons of barytes and 80 tons of bentonite. Variable speed screw conveyors are employed to deliver the chemicals to the mixing tanks. In addition, storage capacity has also been provided for 500 tons of fuel oil, 170 tons of potable water, 900 tons of drilling fresh water or ballast, 140 tons of salt water, and 400 tons of mixed mud.

For cementation of the casing, a Halliburton "T.10" unit has been supplied which can mix and place cement slurry at the rate of 100 tons per hour. This unit can also be used to pump mud and water at pressures up to 10,000 lb per square inch through the drill pipe or well-head should the need arise. A "Schlumberger" well logging outfit will also be carried.

Considerable thought has been given to making the living quarters as comfortable as possible. Air conditioned living and messing accommodation will be provided for up to fifty people. Three 15-ton units will supply air conditioning as well as refrigeration. Fresh water will be manufactured by a flash evaporator, utilising the waste heat from the diesel engines. With five diesel engines running at full load, this unit has a capacity of approximately 770 gallons per hour of fresh water.

The main electricity supply is 440V, three-phase, 50 cycles, and is obtained from three 220kW alternators installed in a generator house which also contains the switchboard from which the various supply circuits are controlled.

The barge is equipped with a Weserhütte "W24S" mobile crane capable of lifting up to 30 tons. This crane is used for landing supplies and personnel from barges which will be moored alongside.

Normal servicing of the drilling barge will be carried out by three general service launches and five 100-ton dumb barges, together with a 600-ton landing craft and a 30-ton refrigerated barge. The drilling barge is also equipped with lifeboats and other life-saving facilities. It has a helicopter landing deck and Westland "Widgeon" helicopters are to be used for urgent and emergency communication between the barge and Das Island base. Radio-telephone equipment is being installed for normal communication with the Island base.

On completion of its manufacture and testing in Germany, the barge will be towed a distance of 6800 miles to Das Island in the Persian Gulf, from where, after fitting-out, it will be towed to the selected drilling site. There the legs will be lowered to the sea bed and the barge elevated to its working position, which will be approximately 40ft above high water level. Drilling operations are due to commence early next year.

Our illustration shows a model of the "Adma Enterprise": a crawler-mounted crane can be seen on deck. The helicopter represented is a Sikorsky "S.55" or "Whirlwind," and considerably larger than the machines actually to be used.

Large Plano-Milling Machine

We illustrate below a heavy plano-milling machine, the model "FL 450/450," designed and built by Schiess Aktiengesellschaft, Düsseldorf-Oberkassel, for the machining of large components weighing up to 150 tons. The machine has an overall length of 151ft, a height of 42ft 8in, a width of 42ft 8in, and a weight of 820 tons, including auxiliary units. Over 120 electric motors are installed, which together total 1250 h.p.

The ribbed and very rigid bed supports the two-piece table, on two flat ways at the outside and two prismatic ways in the centre, over the full length. The machine can deal with workpieces of up to 66ft in length and having a cross section of 15ft by 15ft. Its counterbalanced cross rail has vertical feed motion, and can be fitted with angular milling heads for machining the end faces of large housings. All working parts of the machine, e.g. table, cross rail, heads and milling spindles can be locked electro-hydraulically. This locking occurs automatically when the machine part concerned is not working.

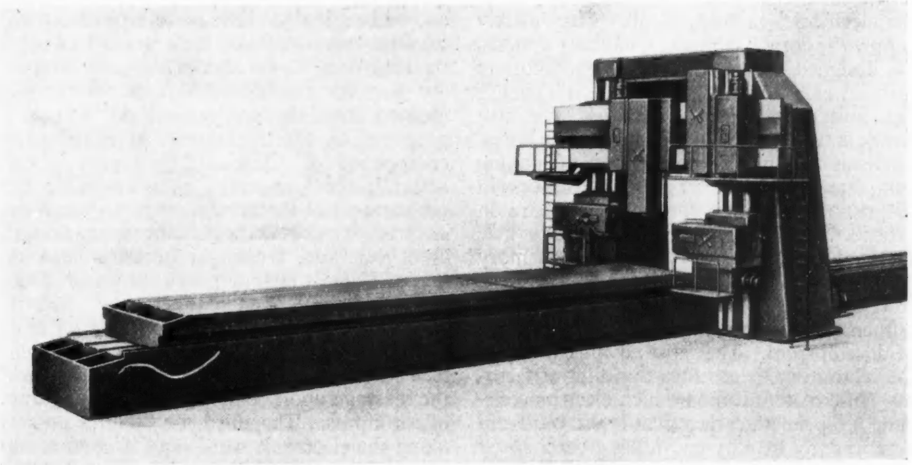
Drive to the table is by d.c. motors, in conjunction with Ward-Leonard converter sets, through helical tooth rack and pinion. Feeds to the table are infinitely variable between 0·060in and 23ft per minute. An independent inching motion for setting purposes is provided.

In order to reduce the time required for the setting up of work, twin tables are fitted so that, when required, work can be set up on one table while machining is in progress on the other table.

The milling spindles have means for hand and power setting, and their drives are provided with stepless control within three electro-hydraulically controlled speed ranges. This arrangement, in conjunction with the steplessly variable control of all the working feeds, makes it possible to choose the best cutting speed for a wide variety of work. The spindle drive for low and medium speeds is transmitted through gears, and for the high speeds by belt, giving speeds from 5 to 560 r.p.m.

The head feeds in the axial direction of the milling spindle range from 0·080in to 5ft 4in per minute. In order to protect the milling cutters and the component, the milling spindles are automatically retracted immediately the cut is completed. Power-operated creep motion has been provided for the rail slide and the spindle head for fine setting.

Precision scales enable the positions of the table and milling heads to be read optically with an accuracy of 0·0004in. The cross rail is fitted with optical means for checking that the slide is set parallel to the table, and a means of motorised fine adjustment is also provided to enable the cross rail to be reset if necessary. In addition, the machine, which can be remotely controlled from two stations, can be fitted with closed circuit television by which all the required measurements are transferred on to a screen at the operator's stand. The Schiess Aktiengesellschaft is represented in the United Kingdom by Burton, Griffiths and Co., Ltd., Kitts Green, Birmingham, 33.



Model "FL 450" plano-milling machine

The American Scene

BY OUR AMERICAN EDITOR

Revolution in Magnetics

In recent years a number of important discoveries and technical developments have greatly increased the applications of permanent magnets and electromagnets in the electrical and electronic industries. Largely as a result of the availability of improved materials—both metallic and, amazingly enough, ceramic—magnets and electromagnetic devices are growing increasingly useful and versatile. On the metallic side, just three steel makers supply most of the basic alloys for magnetic parts : the Allegheny Ludlum Steel Corporation, the Armco Steel Corporation and the Carpenter Steel Company. Three other companies are the prime American producers of ceramic magnetic materials, or " ferrites " : the General Ceramics Corporation, the Stackpole Carbon Company, and a wholly-owned subsidiary of the Dutch Philips concern called the Ferroxcube Corporation. Ferrite materials first were developed shortly after World War II by Philips, who in turn organised the Ferroxcube Corporation to produce these materials in the United States. Over the years, however, the company has devoted its efforts more to research than to production, and to-day the leading American producer is General Ceramics. Turning out ferrites is a difficult business. In the process, a mixture of oxides of various metals, such as iron and manganese, are pressed from powder into small, solid lengths and bonded together with a ceramic adhesive. These are formed into rings or " toroids," which are then placed in a heat-treating furnace, to obtain qualities of extremely high permeability. Until now, the television industry has been the biggest user of ferrite products. However, it generally is acknowledged that their superlative capacity for "memory" work makes them ideal for use in computers. A small ferrite core can replace a vacuum valve as a repository of an electronic charge—or no charge—which means that it stands for zero or one in the binary system of arithmetic. When a computer searches its memory for the coded representation of a fact or figure, the prearranged sequence of ferrite cores, each one either magnetised or not, will spell out the answer. In America to-day the makers of ferrite cores are, strictly speaking, not part of the electronics industry at all. They merely supply the cores ; almost all memory systems are designed by the computer manufacturers themselves. However, this situation is changing, and even General Ceramics, the firm which actually perfected the first ferrite cores, finally is moving in the direction of making complete memories. Further advances in magnetic technology for computers are in prospect. R.C.A., for instance, has a new material which reduces the entire memory " plate " to postage-stamp size. Burroughs, to take the outstanding example, has several refinements of the principle in various stages of development. The most advanced, still in the laboratory, is an ultra-thin film of ferromagnetic material upon which electronic circuits are printed, rather than interlaced from core to core, thereby providing greater speed of access. With this device, it is claimed that facts can be " taken out " and " put back " in just one one-hundred-millionth of a second.

In spite of the growing importance of ceramics, the majority of magnetic devices employ metallic alloys. The " breakthrough" in the technology of these materials occurred shortly before World War II, when the Germans developed a nickel-iron alloy which, when coil-wound, vastly amplified electric current. The German navy put it to use in the first practical magnetic amplifiers during the war. Mounted in the fire control systems of such battleships as the " Bismarck," the invention succeeded in baffling the Allies throughout the war. For whereas a direct hit on a floating target, by shattering the delicate filament elements or the glass vacuum valves of standard electronics devices, was enough to knock out the control systems of the Allies, those of the Germans weathered one battle after another. At the end of the war, the U.S. Navy discovered the composition of the alloy and American production of magnetic amplifiers began on a limited scale. Not until the outbreak of hostilities in Korea, however, did real commercial development take place. In the past seven years, considerable progress has been made in magnetic metallurgy. The nickel-iron alloys have been improved and grain orientation has brought about superior magnetic properties. Each new magnetic alloy has given a fillip to the development of new components. Perhaps the best example is the magnetic amplifier. This device, designed in almost limitless varieties of size and power, has found its biggest market in power and control applications—ranging from static components in generating systems to amplification of current in such devices as automatic pilots, submarine controls and factory-process automation. On the strength of reliability alone—they cannot burn out or be damaged easily—magnetic amplifiers would appear to be the logical successor to vacuum valves in most circuitry. However, the development of transistors and semi-conductors has intervened. The latter are both smaller and better attuned to the precise, steady transmission required in such fields as digital computers. However, the tremendous power-control possible with magnetic amplifiers has opened up such markets as automation equipment. For this work " magamps " are cheaper than transistors, and while initially a little more expensive than vacuum valves, actually cost much less over the long run. Some idea of the potentials of the magnetic amplifier in this sphere may be gleaned from the systems called " Cypak," produced by Westinghouse. As a principal component of Cypak (" packaged cybernetics "), the " magamp " makes possible the replacement of the human sensory system by electronic devices in the guidance of machines. Two years ago, Westinghouse introduced its line of Cypaks in four packaged units. One performs the " And " function ; i.e., it allows a received signal to continue on if it has " heard from " all of the circuits which feed it. Another, the " Or " Cypak, carries the message upon being signalled by any one of its inputs. The third, or " Not," passes along the electronic word only if none of its inputs are conducting current. Finally, the " Nor " or memory Cypak, performs the combination of " Or " and " Not " functions. As part of an overall circuit, such Cypaks can control a multi-operational machine tool or a processing plant.

In addition to these developments in the electromagnetics industry, there are other, even more startling advances. One is a process for precision measuring, evolved out of the work of two physicists, which is being developed independently by two different companies—Varian Associates and Perkin-Elmer. The technique, for which Drs. Edward Purcell, of Harvard, and Felix Block, of Stanford, won the Nobel Prize in 1952, involves the induction of radio frequencies into the nuclei of a substance by the use of a powerful electromagnetic source. The nuclei thus are caused to spin like gyroscopes—each in a manner which makes possible atomic identification of the material. Varian, which is working on the Block method on the West Coast, is understood to have come close to perfecting this magnetic " ultra-spectrometer." Perkin-Elmer, in the east, has acquired the Boston research firm, Nuclear Magnetics, which is pursuing the Harvard findings. What purpose can such a device serve ? Perkin-Elmer believes that the instrument can be of great value to chemical and other process industries. By continuously monitoring the water content in a paper-making plant, for example, a processor might achieve maximum efficiency and quality control. Another interesting development is proceeding at Arthur D. Little, Incorporated. This is the culmination of efforts to find a use for the science of cryogenics—the study of the behaviour of materials at temperatures of almost absolute zero. Little's discovery involves a small strip of tantalum, around which a fine wire of niobium is wrapped. This combination ordinarily lacks electrical conductivity but becomes superconductive in a bath of liquid helium. However, should current be induced into the coil, the creation of a magnetic field stops the conductivity. A hundred of such devices can fit into a thimble and thus offer revolutionary possibilities for computer design. Moreover, the general theory of cryogenics might find many other uses—one possibility is the improvement of radar reception by a considerable degree. The most optimistic experts in the field envisage cryogenics as an eventual replacement for electronics as it is known to-day. Whether such advances will come to pass, of course, remains to be seen. Yet there can be no doubt of the great strides already made and soon to come, thanks to the revolution which is currently taking place in the entire field of magnetics.

Gas Turbine Exposition

THE third annual Gas Turbine Conference and Exposition, which is being sponsored by the Gas Turbine Power Division of the American Society of Mechanical Engineers, will be held in the Shoreham Hotel, Washington, D.C., from March 4 to March 7, 1958. Exhibits will be limited to various gas turbine power plants, component parts, materials, fuels and accessories, while the conference programme calls for the presentation of papers, for discussion, on gas turbine subjects dealing with aircraft, automobiles, industry, ships, railways, fuels and combustion.

Philo Steam Power Station

No. III—(*Concluded from page* 213, *August* 9)

The 120*MW super-pressure unit which went into commercial operation at the Philo power station of the Ohio Power Company in June is to-day the most advanced steam-electric generating plant operating in the United States. While initially operating at less than rated design conditions, the unit is expected ultimately to achieve a net heat rate of* 8530 *B.Th.U. per kilowatt-hour. The boiler has been designed to deliver steam at a pressure of* 4500 *lb per square inch gauge, at a temperature of* 1150 *deg. Fah. and at a rate of* 675,000 *lb per hour. The tandem compound turbine has two stages of reheat, respectively raising the steam temperature from* 800 *deg. to* 1050 *deg. Fah. at* 1225 *lb per square inch gauge and from* 630 *deg. to* 1000 *deg. Fah. at* 185 *lb per square inch gauge.*

FLOW CONTROLS

FLOW below 125,000 lb per hour through either of the pumps automatically opens the emergency leak-off valves on the pump in question. Total feed-water flow of less than 225,000 lb per hour, measured on the total flow meter, trips the unit off the line. The total flow meter also can be used in the primary control if maintenance is required on either of the individual flow meters. A low superheater outlet temperature over-ride is provided to reduce the feed-water flow in either mode of operation if the superheat outlet temperature tends to drop below 1000 deg. Fah. A lockout is provided on this safety device for use during start-up. A pressure switch acts to open the superheater by-pass valves if the pressure at the platen superheater inlet header tends to rise above the set pressure on the safety valves. The by-pass valves function, therefore, as power-relief valves to reduce the number of times the main safety valves will have to open.

The combustion control is concerned with the regulation of heat input to provide the desired outlet steam temperature. Since the ratio of heat input to pounds of water flowing is under the operator's control, the operator may select any desired outlet temperature. In other words, the steam generator does not have a limited temperature characteristic like a subcritical pressure boiler, but an infinite combination of flows and temperatures may be attained. Since it takes approximately two minutes for an element of water to pass through the entire length of this steam generator at full load, there is a considerable time delay between changes in firing rate and changes in outlet steam temperature. It was decided, therefore, to take the primary temperature measurement which would indicate changes in heat input per pound of water from a zone as near the feed-water inlet header as practicable. In passing through the boiler, the feed-water flows first through the three cyclones and their associated walls in series. The water temperature leaving the cyclones is very nearly the conversion zone temperature of slightly above 700 deg. Fah. This is a zone of temperature where shadowy discontinuities of some properties, such as specific heat, exist as reminders of the evaporative process below the critical pressure.

The conversion zone temperature was selected as the anticipator to force the firing rate up or down during transient conditions. Subsequent response-rate tests on the small steam generator at the Babcock and Wilcox Research Centre indicated the correctness of this choice. From stabilised conditions, a sudden increase in water flow with no change in firing rate caused outlet steam temperature to rise first and then, after an appreciable interval, drop below the original conditions. The conversion zone temperature, however, dropped immediately to a new level, showing correct direction and good speed of response. The conversion zone temperature, although not controlled at any particular level over the load range of the unit, is used as the anticipator to modify firing rate. The signal for combustion control, therefore, comes from a total water flow measurement, modified by conversion zone temperature and final steam temperature. This master combustion control signal regulates air flow through each of the cyclones. Air flow, in turn, determines the coal feed to each of the cyclones. Oxygen analysis equipment is used as a bias for each of the cyclones to obtain the optimum air-fuel ratio. The vane positions of the induced-draught fans are controlled by furnace draught. Recirculation gas flow is automatically proportioned to the total air flow through the unit and corrected by the gas temperature in the convection pass. This proportion may be biased by the operator, who observes slagging conditions in the pendant superheater and judges whether the gas temperature entering this zone should be increased or decreased by lowering or raising the flow of recirculating gas.

Reheat steam temperatures are controlled by positioning the gas dampers in the outlet of the convection pass. These dampers cross the back of the primary superheater pass on the left-hand side of the unit, and the reheater pass on the right-hand side. The two reheaters are in series in the gas pass so that gas-side control of both reheat temperatures would have been exceedingly difficult. The alternative possibilities were : (1) To control to whichever temperature was lower relative to design value and attemperate ahead of the other reheater to keep its outlet temperature down to the design value. (2) Or to control to whichever temperature was higher and let the other temperature sag.

Thermodynamic studies indicated that the loss to the cycle efficiency due to attemperation was about equal to the loss due to lowering one of the reheat temperatures. The second method of control was chosen because it is less complicated. Space has been left in the cold reheat lines, however, for the subsequent inclusion of attemperators if they should prove desirable. Since storage in the de-ærator is limited to approximately two minutes flow at full load, the de-ærator level controls the flow from the condensate booster pumps. The hot-well level is controlled by the addition of make-up to the cycle or by the routing of condensate to storage. Automatic heater-level controls are utilised on each of the feed-water heaters.

Throughout the design of this unit, the basic concept of automatic control has been observed. All control functions are either completely automatic or are under the operator's control remotely from the central control room which is situated on the turbine-room floor alongside the high-pressure machine. To supervise the operation of the unit, extensive instrumentation has been provided. All important functions are recorded in full view of the operator, and other functions are either indicated or provided with alarms.

FEED PUMPS AND HEATERS

In the design of this cycle, the position of the de-aerator was determined by other than thermodynamic considerations. The de-aerator serves to place the boiler feed pumps at a somewhat higher temperature level than might otherwise have been selected. When the boiler feed pump was tentatively situated under the de-aerator, designs were considered for the two high-pressure feed-water heaters suitable for operation at the full feed-water pressure of 5500 lb per square inch. Designed along conventional lines, these heaters reached large dimensions and were considerably more expensive than two conventional heaters designed for 2100 lb per square inch. Although the heat rate suffered, the power company was forced by this differential in heater cost to go to a split pump arrangement. It is felt that in the future, designs will be developed allowing economical high-pressure feed-water heaters to be built to overcome the extra cost and complication of splitting the pumps.

In the present arrangement, two constant-speed pumps rated at 924 g.p.m. at 3550 r.p.m. with twelve stages take suction from the de-aerator and raise pressure to 2100 lb per square inch. The feed-water is then heated in two high-pressure feed-water heaters, the sixteenth-stage heater operating at 447 lb per square inch absolute, and the eleventh-stage heater operating at 819 lb per square inch absolute to 510·8 deg. Fah. Two variable-speed, eight-stage pumps rated at 1027 g.p.m. at 6500 r.p.m. then raise the pressure to 5450 lb per square inch absolute. The estimated efficiency of both pumps is 78 per cent. The feed-water temperature is raised from 510·8 deg. to 525 deg. Fah. in the variable-speed pumps.

One of the low-pressure and one of the high-pressure pumps have been coupled to a single motor in a tandem arrangement. One shaft end of a 4000 h.p., 3550 r.p.m. induction motor is directly connected to the low-pressure feed pump through a flexible coupling. The other end of the motor shaft is directly coupled to a fluid drive coupling rated 3000 h.p. at 3550 r.p.m., having twin oil coolers. The coupling, in turn, is connected to a step-up gear with a ratio of 1·88 to drive the high-pressure pump at 6500 r.p.m. The feed-water output from the pumps is regulated by controlling the speed of the high-pressure pump. A complete speed range on the coupling has been provided for by suitably sizing the oil coolers so that the main unit can be operated at variable pressures down to the discharge pressure of the constant-speed, low-pressure pumps. The overall length of each pump unit is approximately 42ft. Each set of pumps is protected by a pair of emergency leak-off valves in parallel, with a combined capacity of 125,000 lb per hour at 5500 lb per square inch inlet pressure and 200 lb per square inch discharge pressure. Flashing water from these valves is carried back to a centrifugal separator and flash pot on the side of the de-aerator.

The rotor of the high-pressure pump is balanced by opposing impellers so that no balancing drum is needed. Any small unbalance is taken by a thrust bearing. The low-pressure pump has all stages facing in one direction. Hydraulic balance is maintained by a balancing drum arrangement on the discharge end. The seals on these pumps are particularly critical. The manufacturer proposed a packingless arrangement, utilising two floating bushings. On the low-pressure pump, cool condensate from the condensate booster pumps at 250 lb per square inch is injected into a chamber surrounding the two floating bushings to quench flashing on the suction end of the pump. Any pressure differential from 250 lb per square inch, inward to the suction pressure and outward to atmospheric pressure, spreads the two floating bushings out against ground radial sealing surfaces. At the discharge end of the pump the arrangement is similar, but the seals operate against the balancing drum leak-off which is piped to the de-aerator. The floating bushings allow close clearances which are maintained by the bushings positioning themselves to any shaft running condition.

A similar arrangement was proposed for the high-pressure pump seals. This would have required a source of cool water at approximately 2100 lb per square inch. The only simple way to obtain this water would have been to extract the necessary amount from the discharge of the low-pressure feed pumps and cool it sufficiently to do the required quenching. It was estimated that a total of 60 g.p.m. would have been required at approximately 150 deg. Fah. This would have meant degrading roughly 6,000,000 B.Th.U. per hour from a temperature level of 375 deg. Fah. down to 150 deg. Fah. The power company felt that this was an unnecessarily heavy burden on the heat rate. In the final design which was adopted the pressure is broken down to de-aerator pressure in a floating bushing arrangement. Since the water enters the pump at 510·8 deg. Fah. this means that there is some flashing. Stainless materials have been utilised in this area on the bushings and shaft sleeves to minimise damage. Outside of this leak-off is another pair of floating bushings with a cool water injection identical to the low-pressure pump seals. The inward flow of cool injection water from these seals quenches almost immediately the flashing of the mixture coming from the inner bushings.

Once the decision had been made to split the feed pumps into two sections each, the two high-pressure feed-water heaters became standard heaters operating at 2100 lb per square inch. The eleventh-stage heater, drawing its extraction steam from the high-power turbine exhaust, has a nominal steam side operating pressure of 819 lb per square inch absolute, although its design pressure is 1300 lb per square inch absolute, so that the throttling device in the extraction line to this heater can be removed. The heater was designed with a terminal temperature difference of 10 deg. Fah. to reduce its size since the low terminal temperature difference was, in effect, being wasted by throttling in the extraction line to the heater. The duty on the heater with 510·8 deg. Fah. outlet temperature is 43,200,000 B.Th.U. per hour. The sixteenth-stage heater, taking extraction from the sixteenth stage in the first reheat section of the turbine, has an operating pressure of 465 lb per square inch absolute with a design pressure of 500 lb per square inch absolute and a terminal temperature difference of zero deg. Fah. The duty on the heater at full load is 53,100,000 B.Th.U. per hour. Both heaters have 10 deg. Fah. drain coolers and utilise $\frac{5}{8}$in O.D. 70–30 cupro-nickel tubes. The drains from the eleventh-stage heater are dumped to the sixteenth-stage heater through an automatic level control valve. The sixteenth-stage heater drains are dumped through automatic level control valves to the condenser during start-up and to the de-aerator when the pressure difference between the two becomes large enough to overcome a large static head existing between the two. The 70–30 cupro-nickel tubes have been used in the low-pressure heaters because of the high pH value of the feed-water.

CONDENSER DESIGN

A special condenser design has been utilised to suit the severe conditions which this cycle imposes. The 70–30 cupro-nickel tubes and steel instead of Muntz-metal tube sheets have been used to minimise ammonia attack. The tube sheets inside the water box and the tube ends have been rubber coated to reduce the possibility of leakage. The air-cooler section, which is probably most vulnerable to attack, has been designed so that only a small number of tubes is used. The water-box covers have special manholes so that these tubes can be replaced without removing the entire water-box cover. Two special spray pipes have been introduced into the neck of the condenser. One discharges steam at 300 deg. Fah. maximum from the high-pressure flash tank, and the other sprays in cool condensate to blanket this steam to prevent the heat from backing up into the turbine exhaust. Because of the large movement and high temperature, a water-cooled Philips joint was used to take the expansion of the long exhaust neck.

ELECTRICAL EQUIPMENT

The Unit 6 generator is tied through a three-phase, 15/132kV, 150,000kVA transformer to the two existing 132kV busbars at Philo. Auxiliary power at 4kV is normally supplied to two busbars by a 12,500kVA transformer tied directly to the generator leads. For start-up and emergency conditions a second auxiliary transformer supplies power to these busbars directly from the main 132kV busbars. Large motors which generally are used in pairs are tied alternately to the two 4kV bus sections. This includes the 4000 h.p. feed-pump motors, the forced and induced-draught fans, the recirculating gas fans, condensate booster pumps, and others. Two sections of 550V bus are provided to service smaller auxiliaries. These busbars are served by two 4kV/550V, 1200kVA transformers.

STARTING EQUIPMENT

An external recirculating system is required with a once-through boiler to replace the natural circulation which exists in a conventional boiler even during start-up. Cold condensate must first be circulated as the fires are started and then progressively hotter water and later steam must be disposed of until the steam at the superheater outlet is at a condition suitable for starting the main turbine. To protect the cyclone and furnace-wall tubes the power company adopted the basic operating maxim of not firing unless at least 225,000 lb per hour of water is circulating. This was based upon a minimum water velocity of 7ft per second through the cyclone tubes. Interlocks have been provided to shut off all fires if flow should at any time drop below this minimum amount.

The recirculation system is one of the major points of difference between a conventional boiler and the once-through boiler. The design of this system represented one of the most challenging problems associated with the design of the unit as a whole. All equipment had to be designed for completely tight shut-off against full pressure and temperature conditions. In operation, the piping and valves must withstand pressure drops from 4500 lb per square inch down to 150 lb per square inch at all temperatures between room temperature and 1150 deg. Fah. In starting up and in passing through this spectrum of temperatures, the valves must pass first a waterlike phase, later steam which flashes wet and then dry again and, finally, completely superheated steam. This imposes particularly severe service on these valves.

Two means of recirculation were provided : the first and main one is the turbine by-pass system which is normally used in starting and shutting down the unit ; the second one is the superheater by-pass system which was provided to maintain flow through the boiler in the event of unit trip-out and to assist in restarting the boiler from a hot bottled condition. The turbine by-pass system as originally conceived had an intimate relation with the turbine controls. It was intended that the turbine by-pass would open whenever the turbine throttle flow dropped below the limiting 225,000 lb per hour amount. This arrangement was out of the question, however, without keeping the whole by-pass system up to, or near, main steam temperature to prevent thermal shock to the heavy austenitic sections when the by-pass valves popped open. This constant warming was considered too costly and complicated. The turbine by-pass system is, therefore, only opened gradually under the operator's control. The function of maintaining some flow through the boiler during trip-out was taken over by the superheater by-pass valve.

During the starting period, it is advisable gradually and uniformly to warm up as much of the heavy-walled pressure parts in the cycle as possible. The connection to the by-pass system was moved as close to the turbine as possible by substituting it for the above seat drains on the turbine stop valves. The whole system, therefore, from the feed-water header through the steam generator and the four main steam leads to the stop-valve bodies is warmed during starting. Each section of pipe from a bend above the superheater outlet header on down through the main steam leads to the stop valves and down to the recirculating system, ultimately ending in the condenser, is pitched downward to provide complete drainage. Two lines from the above-seat drain taps on the two left-hand stop valves are tied together in a single line leading to one turbine by-pass stop valve. The two right-hand stop valves are similarly tied to the other turbine by-pass stop valves. The lines leading from the individual main turbine stop valves to the two single lines leading to the by-pass stop valves are carefully placed in a horizontal plane so that water cannot collect in them and then be blown from one stop-valve body into the other when the first stop valve is closed for test with load on the unit. From the two by-pass stop valves, which were provided for complete tight shut-off of this system, the fluid flows into a common valve header with eight small control valves. The two stop valves and the eight control valves are operated by a common camshaft which is positioned by an oil-operated cylinder. Specially designed divergent nozzles in the throats of these valves absorb the high-pressure drop and release the steam into a large header.

The superheater by-pass system consists of two air-operated valves in parallel situated above the platen superheater inlet header. Steam in this header at full load on the unit is at 4700 lb per square inch and 900 deg. Fah. These valves have a capacity of 112,500 lb per hour each. At full flow about 4500 lb per square inch pressure drop is taken in the valve and the divergent section below it. These valves are situated so that the line above the seat is pitched back to the platen superheater inlet header, and the line below the seat is pitched downward to the by-pass system. The piping immediately following the divergent section below these valves is 10in standard weight pipe protected with safety valves set at 240 lb per square inch. In a full-load trip-out when the superheater by-pass valves automatically open to pass steam at 900 deg. Fah., the throttling effect of dropping pressure to 150 lb per square inch cools the steam down to approximately 700 deg. Fah. The thermal shock of instantly opening these valves and exposing the low-pressure parts of the breakdown system to 700 deg. Fah. is not severe, especially since the piping in this area is of ferritic material which is better able to take thermal shock than austenitic material. 14in pipelines connect the outlets of the turbine by-pass system and the superheater by-pass system. An attemperator is provided in this common line with adequate capacity to cool the steam to the saturation temperature corresponding to a pressure of 150 lb per square inch or lower.

Originally, it had been the intention to use the de-aerator as the point into which this recirculated steam would be dumped. Later in the design phase it became increasingly apparent that soluble salts deposited in the steam generator might wash out during the starting and shutting-down procedures. To avoid contaminating the de-aerator water and the top part of the condensate cycle with these salts, it was decided to purify all condensate used during the start-up or shut-down cycle before it was returned to the feed-water cycle. This is accomplished by passing all the recirculated steam-and-water mixture through two flash separators, in series, where dry and clean steam is separated by centrifugal action from the water containing any solids. The clean steam is dumped into the condenser, where it is condensed and returned to the cycle. The condensate from the two flash tanks is returned either to the cycle after having been filtered and demineralised or to a dirty-water storage tank for a later clean-up. If water is being sent to the dirty-water storage tank, condensate is made up to the cycle from the main condensate storage tank.

The attemperator in the recirculating line is sized so that at all times wet steam will enter the first flash-separator tank. This tank is designed to operate at 150 lb per square inch and is a cyclone separator. Level is maintained near the bottom of the tank by level-control valves and steam is removed from the top section of the tank through steam scrubbers and pressure regulating valve set to maintain 150 lb per square inch to the condenser. Saturated water at 150 lb per square inch pressure drains from the high-pressure flash tank to the low-pressure flash tank, which is similar in design but operates at 5 lb per square inch absolute maximum pressure. This tank is directly connected to the steam space of the condenser. Drips from this tank are pumped to the dirty-water storage system or through the filter and demineraliser back into the main condensate cycle. Means are provided to dump these drips directly to the condenser in the event that they are sufficiently pure.

STARTING PROCEDURE

Normal cold start-up of this unit is accomplished in general in the following steps : (1) Close feed-pump discharge valves and start one feed pump, hot well and condensate booster pumps. (2) Open turbine by-pass valves and feed-pump shut-off valve by-pass to establish flow through steam generator. (3) Build up pressure by throttling on turbine by-pass valves. (4) When steam generator is up to full pressure, open feed-pump discharge valve. (5) Establish 225,000 lb per hour flow through steam generator and put pressure control on turbine by-pass pressure regulator. (6) Start induced-draught, forced-draught and recirculating gas fans, and light off one cyclone. (7) Fire to raise fluid temperature leaving steam generator from room temperature up to approximately 900 deg. Fah. (8) Start turbine under speed governor control. (9) Regulate firing to maintain outlet steam temperature and load turbine with speed governor. As the turbine is loaded, hold feed-water flow constant and allow turbine by-pass pressure regulator to reduce turbine by-pass flow automatically. (10) After turbine by-pass valves are fully closed, increase feed-water flow and temperature until unit is brought to full load.

In a normal shut-down, the following steps are taken : (1) Reduce load and temperature on the unit until flow is 225,000 lb per hour and temperature is approximately 900 deg. to 1000 deg. Fah. (2) Gradually warm and then open turbine by-pass system until it is taking about 100,000 lb per hour of total 225,000 lb per hour flow. (3) Trip-off turbine and steam generator and reduce turbine by-pass flow to a value which will give an acceptable cooling rate in the steam generator and associated piping. (4) Circulate water until steam generator is entirely cooled. (5) Store steam generator full of water.

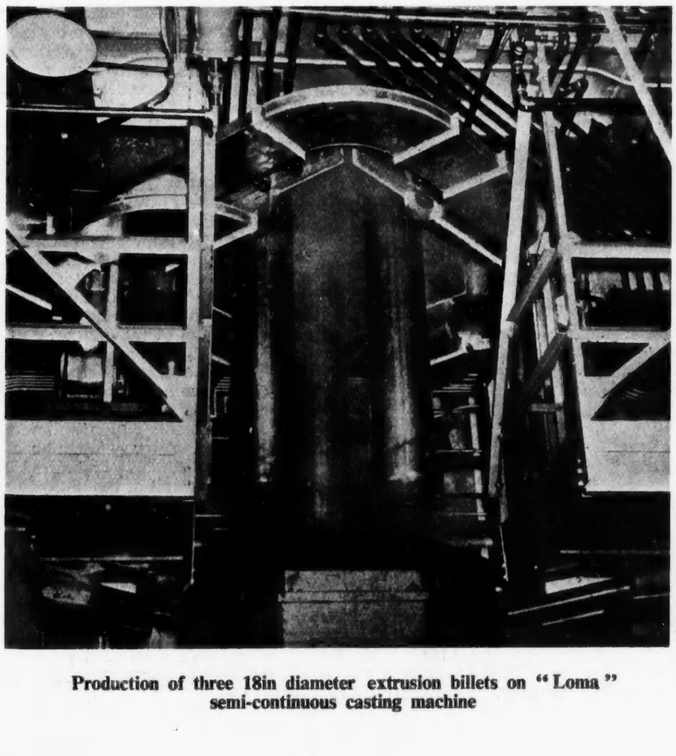
In the event of loss of electrical load or trip-out of the unit by any of the relays previously described, all valves will trip shut on the turbine and one superheater by-pass valve will open to maintain some minimum flow through the steam generator. In a short time the slag and setting will have cooled and this valve will be shut. If there is any chance of restarting the unit within several hours, pressure will be maintained. If the cause of trip-out is corrected, the following steps are taken to restart the unit : (1) Open both superheater by-pass valves to give 225,000 lb per hour flow. (2) Immediately fire at one-third full load heat input and adjust to hold steam temperature as near metal temperatures as possible at the platen superheater outlet header. Operate recirculating gas fans as necessary to prevent overheating of secondary superheater tubes, which have no steam flow through them. (3) When steam temperature at the superheater by-pass is stabilised, open turbine by-pass gradually and close superheater by-pass to establish flow through the secondary superheater. (4) When all flow has been transferred to the turbine by-pass, fire the steam generator to bring main steam temperature up to match metal temperatures in the front end of the turbine. (5) Start turbine and load as in ordinary cold start procedure.

Continuous Casting of Large Extrusion Billets

AMONG the processing plant installed at the recently completed U.S. Air Force Heavy Press Extrusion Works, operated by the Kaiser Aluminum and Chemical Corporation at Halethorpe, Maryland, are two interesting vertical "D.C." or "direct-chill" billet casting machines, which are equipped with unusually productive billet handling equipment. A wide variety of aluminium alloys is produced by the extrusion works, and the Kaiser concern has been particularly successful in casting even highly alloyed billets with an excellent metallurgical structure, entirely free from inverse segregation. Hot metal for the casting operation is obtained from four gas-fired reverberatory furnaces having a melting capacity of 50,000 lb each. The metal flows from the holding hearth of the furnaces through a refractory-lined and electrically heated swinging trough into a distributing pan, and finally through spouts into the water-cooled aluminium moulds.

The fundamental design of the "D.C." casting machines at Halethorpe was developed by Kaiser Aluminum, and the mechanical part of these units was designed and constructed by the Loma Machine Manufacturing Company, of New York. The machines operate on a semi-continuous basis, and are capable of producing billets, or "logs," up to 25ft length and up to 20in diameter. Depending upon the diameter being cast, each machine can produce two or more billets simultaneously, as illustrated. The results obtained with this casting equipment have been excellent, with the billet surface being so clean as to require no scalping prior to extrusion, even in the high-strength alloys. For the extrusion of large tubes the "logs" are cast hollow and then scalped internally to be used in conjunction with mandrels in the presses. The casting machines operate at an infinitely variable billet lowering speed up to 8in per minute, and a fixed billet lifting speed of 90in per minute. The hydraulic equipment for lowering and lifting the mould stool supporting platform comprises a cylinder of almost 30ft stroke, an oil-hydraulic power unit and control gear to regulate the length and rate of platform travel. The hydraulic system is capable of supporting a maximum billet load of approximately 20,000 lb.

The high productivity of the casting installation at Halethorpe is facilitated largely by a patented automatic billet removal device, which was also designed and constructed by the Loma firm. This equipment eliminates the need for overhead crane facilities and ensures rapid and smooth transfer of the billets from the casting machines to the receiving racks. Furthermore, it avoids the need for the mould set-up to be moved during billet handling operations. As soon as an individual pour is completed, the 25ft long billets are supported in the vertical position by a series of guides. The billet grab arm is then advanced and made to pick up one billet at a time by means oil-hydraulic cylinders. The entire removal device is mounted on a carriage which moves on rails across the casting machine. A combination of tilting the billet grab arm, and moving the carriage away from the casting pit causes the billet to swing from the vertical beyond the horizontal position and allows it to be unloaded to a sloped idle roller conveyor incorporating a 5-ton weighing scale. Finally, the "log" is pushed on to a billet receiving rack where it is tested ultrasonically prior to transfer to the homogenising furnaces or the billet saw.


Production of three 18in diameter extrusion billets on "Loma" semi-continuous casting machine

The Halethorpe works is using the casting installation in the production of extrusion billets of such American aluminium alloys as 6061, 6062, 2024 and 7075. In the field of heavy press extrusions, and in the related field of rolled aluminium alloy products, strict quality requirements apply, and another large casting installation consisting of six stations for the semi-continuous production of rolling mill slabs weighing up to 20,000 lb each is currently being built by the Loma Machine Manufacturing Company for the new Kaiser Aluminum works at Ravenswood, West Virginia.

Irrigation Water Supply in the Western States

AN adequate supply of irrigation water for this season now seems certain for most schemes of the U.S. Bureau of Reclamation as continuing rainstorms throughout much of the west and south-west are filling reservoirs that four to six years of drought had nearly emptied. Many reservoirs in the seventeen western States are filling for the first time in years and some are spilling. As rainstorms continue, the Bureau is already operating some storage reservoirs for flood control purposes. Drought to flood and back to drought again is the pattern of precipitation in the west, and it is precisely to meet and solve this problem that the Bureau builds its structures. In good water years, such as this year promises to be, the reservoirs are filled to tide irrigators over succeeding years of water shortage. In the Pacific north-west, the water supply prospects are fair to excellent and most reservoirs are full or nearly full. In California's Central Valley, the reservoirs are full with some spilling. For the first time, Shasta Lake has been operated for flood storage during the month of May. It reached its highest recorded storage on May 19. The reservoirs are full on the Klamath and Orland projects. The outlook on the Cachuma project is only fair, since the newly completed reservoir is filling slowly.

Precipitation in the Upper Colorado River catchment area during May was about 246 per cent of the thirty-four year average for the month and total seasonal precipitation increased to about 147 per cent. Floods are to be expected on uncontrolled streams where precipitation has been highest. While the spring inflow to Lake Mead continued to improve, it is possible that considerable losses could result from run-off starting so late in the watershed. Record precipitation was reported over south-western Wyoming, northern Utah, and western Colorado for May. With a heavy snowpack at higher elevations, warm weather brought some flooding. The water supply for projects in Nevada and eastern and southern Utah is fair. Water conditions on the Middle Rio Grande and Rio Grande projects should improve if the present run-off continues, although a critical shortage still exists. While there has been little rain in New Mexico, recent rains have filled the reservoirs in Okalahoma and Texas. Most areas served by the reservoirs on the upper Missouri River watershed will have sufficient irrigation water for summer needs. Heavy precipitation has improved the situation on the lower Missouri River watershed. Low irrigation demands and temperatures below normal combined to ensure a good water year. Many reservoirs are full and flood control operations have been initiated on many projects. Precipitation has ranged from 150 to 300 per cent of normal above reservoirs of the Colorado-Big Thompson project serving north-eastern Colorado, thus providing ample water for supplemental irrigation.

Sale of Heavy Water to Australia

A CONTRACT for the sale of 10 tons of heavy water by the United States to Australia, for use in a materials testing and research reactor being constructed by the Australian Atomic Energy Commission at its Lucas Heights research establishment near Sydney, was signed recently. The construction of the reactor, known as the High Flux Australian Reactor (HIFAR), began in October, 1955, and it is scheduled to go into operation early in 1958. It is the first nuclear reactor to be constructed in Australia. The heavy water is being purchased under the terms of an agreement for co-operation on the civil uses of atomic energy between the United States and Australia. The cost of the heavy water is 28 dollars per pound.

Personal and Business

Appointments

Mr. Edgar P. Heather has been appointed a director of Wadkin, Ltd.

Mr. J. B. Denison has been elected president of the Institution of Mining and Metallurgy for 1958-59.

V. L. Farthing and Co., Ltd., has announced the appointment of Mr. A. F. Peart as manager of its London office.

Mr. W. M. B. Lamb has been appointed purshasing agent for the Canadian Pacific Railway in Europe with headquarters in London.

Concrete, Ltd., has announced that it has appointed Mr. Kenneth Weeks to be an additional representative in the Midlands area.

Remington Rand, Ltd., has announced that Mr. J. O. V. Christian has been appointed to the newly created position of product manager.

British Railways, London Midland Region, has announced that Mr. George Brian Gray, general agent, Dublin, has been appointed divisional traffic manager, Barrow.

The Association of U.K. Plier Manufacturers has announced the appointment of Mr. E. A. Tuxford as secretary in succession to the late Mr. J. L. Watchurst.

Laycock Engineering, Ltd., Garage Equipment Division, has announced that Mr. G. W. Newbould has been appointed S. Yorkshire and N. Midlands representative in succession to Mr. D. H. Langley.

Mr. G. H. Hinds, electronics advisory officer, British Transport Commission, has been appointed a member of the general board of the National Physical Laboratory. Mr. Hinds will also serve on the advisory committee on high-speed calculating machines, Department of Scientific and Industrial Research.

The Cape Asbestos Company, Ltd., has announced that Mr. Robert Walker, chairman, has decided to retire from the board of directors on August 31. Mr. Giles Newton has been elected chairman and Mr. R. H. Dent and Mr. T. C. Hale have been appointed joint managing directors. Mr. T. Muir Warden has been appointed a director.

Lloyd's Register of Shipping states that Mr. H. P. Southwell, deputy to the Chief Surveyors (Establishment), is to retire in September 30 and his duties will be shared by Mr. J. McAfee who will be designated Assistant Chief Engineer (Staff) and Mr. J. A. Mavor who will be promoted to Assistant Chief Ship Surveyor (Staff). Mr. Mavor will be succeeded as principal surveyor for Italy by Mr. F. N. Boylan.

E.M.I. Sales and Service, Ltd., has announced the following appointments :—Mr. R. J. T. Hewitt, general manager, and to act as deputy to the managing director ; Mr. H. S. Futter, publicity manager, to be directly responsible to the managing director for all publicity and advertising matters, and Mr. F. L. V. Offord, export manager, to be directly responsible to the managing director for the promotion of all export business.

Business Announcements

F. Perkins, Ltd., announces that its " P6(V) " vehicle diesel engine is now being manufactured at the plant of Simpson and Co., Ltd., Madras, following upon an agreement between F. Perkins, Ltd., and the Government of India.

The Solartron Electronic Group, Ltd., Thames Ditton, Surrey, states that it has decided to sell no longer through agents in the United Kingdom, and that in future all inquiries should be sent direct to the group at Thames Ditton.

George H. Alexander Machinery, Ltd., 82-84, Coleshill Street, Birmingham, 4, states that it has been appointed sole agent in the United Kingdom and Eire for the ultrasonic equipment made by Dr. Lehfeldt and Co., Heppenheim, Germany.

D. Napier and Son, Ltd., announces the formation of a subsidiary, Napier Engines Incorporated, in Washington, D.C. The new company is to sell Napier products, contract for the overhaul of Napier engines, and provide a spares service in the U.S.A.

Rockwell Machine Tool Company, Ltd., Welsh Harp, Edgware Road, London, N.W.2, states that it has been appointed sole selling agent in the United Kingdom for the heavy-duty fine boring machine manufactured by Henry Milnes, Ltd., Bradford, Yorks.

Lloyd's Register of Shipping announces the formation of a National Committee in Italy of which the inaugural meeting was held in Genoa on July 22, when Dr. Francesco Manzitti was elected chairman and Dott. Ing. Carlo Antonio Calcagno and Gr. Uff. Ugo Fassio, deputy chairmen.

Oliver Pell Control, Ltd., states that the production of " Varley " range of transformers has now been concentrated in the new factory of Redcliffe Industries (Bristol), Ltd., Emery Road, Brislington, Bristol, 4, and that in future Oliver Pell Control, Ltd., will market both ranges as " Redcliffe " transformers only.

Expandite, Ltd., states that Mr. J. Masterton, overseas technical representative, will leave this country on September 4, and will visit Lybia, Belgian Congo and the Central African Federation; Mr. A. E. Potter, a director of Expandite, Ltd., has left this country for a tour covering the company's interests in Australia, New Zealand and India.

Contracts

The Decca Navigator Company, Ltd., has received an order from the Indian Government for two Decca navigator chains, one to be centred on Bombay and the other to be installed at Calcutta.

The English Electric Export and Trading Company, Ltd., has received a further order from the U.S. Army Corps of Engineers for Table Rock Power Station, White River, Missouri. The first order, for two water turbines, vertical Francis type, 68,000 h.p. at 128·6 r.p.m. under a 190ft head, was received in November, 1954, and is now nearing completion in the company's works at Rugby and Netherton, near Liverpool. The latest order is for the supply of numbers three and four water turbines of similar design and power to the first two. The value of the contract is in the region of $1,400,000. The turbines will be built at Rugby and Netherton.

Newton Chambers and Co., Ltd., Engineering Division, Thorncliffe, near Sheffield, has received an order from the British Cast Iron Research Association for an experimental hot blast cupola installation at Alvechurch, near Birmingham. The installation will incorporate the " INKA " radiant air preheater for which Newton Chambers have recently concluded a licence agreement with Industriekemiska Aktiebolaget, Stockholm. The contract with the B.I.C.R.A. was negotiated jointly with the Constructional Engineering Company, Ltd., Birmingham, and this company will be responsible for the installation of the cupola and certain other ancillary equipment.

Australian Electrical Industries Pty., Ltd., acting on behalf of Metropolitan-Vickers Electrical Export Company, Ltd., has received from the State Electricity Commission of Victoria, Australia, an order for Yallourn " E " power station. The station will have an output of 240MW, and the order, worth £4,400,000 sterling, is for the complete power station with the exception of the boilers and coal handling plant. Equipment worth £2,500,000 sterling is to be manufactured at the Metropolitan-Vickers Trafford Park Works, the main items being the two turbine-generator sets and the main transformers. Each turbine-generator set will each have an output of 120MW at 13·8kV three-phase 50 cycles and will consist of hydrogen-cooled generators direct coupled to turbines running at 3000 r.p.m. The turbines, of two-cylinder close-coupled construction, will be non-re-heat machines with inlet steam conditions of 1500 lb per square inch gauge at 1050 deg. Fah. The main transformers will be two three-phase groups of single-phase units to step-up the generator voltage to the 345kV transmission voltage. Initially the transformers will supply power at 230kV, and the change-over to the higher voltage will be made by means of adjusting links. Off-circuit adjusting tappings will be provided on the 345kV windings at minus 2½, 5, 7½ and 10 per cent.

Miscellanea

Exhibition of Telecommunications Equipment.—Products of its various British factories have been privately exhibited by Standard Telephones and Cables, Ltd., at New Southgate, London. The company's seventy-fifth anniversary falls in a few months, but the current programme rather than the history behind it was the theme in the minds of the organisers of the exhibition. Nevertheless, visitors were also invited to inspect the McVitie Weston valve collection, consisting of more than 2000 specimens, which is in the custody of the company.

Last Heat Exchanger in Position at Calder Hall.—The last of sixteen Babcock and Wilcox heat exchangers has been erected at Calder Hall nuclear power station. Each of these pieces of equipment weighs 178 tons, is 80ft high, and has a diameter of 17ft 6in. The erection of the heat exchangers was carried out over about three years by the constructional division of Costain-John Brown, Ltd.

Mr. R. V. Perfect.—We have learned with regret of the death of Mr. Robert Verdon Perfect which occurred suddenly in Sydney, Australia, on August 4. Mr. Perfect, who was born in 1904, started his career as an apprentice with A. V. Roe and Co. and joined Saunders-Roe, Ltd., in 1929, becoming successively outside representative, works manager, work director in 1941 and sales and publicity director in 1946.

Electric Tool Works in India.—Under a joint scheme between Wolf Electric Tools, Ltd., and Rallis India, Ltd., a manufacturing plant for electric tools has been established on the outskirts of Bombay. This plant has been organised along established British lines and is in full production. The first batch of Indian assembled " Wolf " electric tools was completed last October, since when output has included standard and heavy-duty drills ranging from ¼in to ¾in capacity, including the " Wolf Cub " home handyman drill.

Fast Run on British Railways.—On Wednesday August 7, " The Caledonian," express train of the London Midland Region, made its fastest run, covering the 401 miles Glasgow to Euston in 387 minutes. This journey was made in 13 minutes less than the scheduled time of 6 hours 40 minutes, and was 3 minutes less than that of the pre-war " Coronation Scot." The eight-coach train, which makes a stop at Carlisle, was hauled on this record run by locomotive No. 46229, the " Duchess of Hamilton."

Doppler Accuracy.—The performance of a police radar speedometer has been investigated by the Automobile Association. The instrument functions at 2455 Mc/s, the oscillator frequency having a tolerance of ±1 Mc/s ; the makers claim an accuracy of ±2 m.p.h. under favourable conditions. It was found that variations in the battery voltage resulted in errors up to 6 m.p.h., and that the presence of objects, moving or stationary, near to the target was prejudicial. The instrument was also affected by ambient temperature, and its range was no more than 60 yards.

Roll Cladding.—A method for the external cladding of rolls, shafts, tubes and drums with stainless steel has been introduced at the Hull works of Rose, Downs and Thompson, Ltd. This patented process is of Continental origin and is stated to provide a perfect bond between the cladding material and the foundation body. The process is stated to be particularly advantageous in cases where internally heated or cooled rolls and drums, after cladding, are required for working in a very wide range of temperatures. It is claimed that rolls and shafts protected by this form of cladding are suitable for working in temperatures from −40 deg. to 300 deg. Cent. Clad rolls can be ground and polished to precision limits, and whilst stainless steel is the most usual cladding material, the process can be applied equally successfully to other similar materials.

Laminated Timber in Railway Station Construction.—We are informed by the London Midland Region of British Railways that the use of laminated timber for the recent reconstruction of the low level roofs over bays 5 and 6 at Preston station represents a new development in railway station architecture. It is the first time that laminated timber has been used structurally in the region and it is considered that the ease of erection of the prefabricated units makes further use of laminated timber likely where practicable. The roof at Preston consists of laminated column and cantilever beam units arranged with pairs of columns spaced along the platform forming a series of portals, each with cantilevers overhanging the two platforms. A heavy longitudinal beam is placed over each row of columns, and carries a transverse beam and cantilever unit at the mid-point of each span. The total contract consisted of 111 laminated components together with thirty-four laminated timber brackets. Splice plates and standard shear plate connectors of 2⅝in diameter were used at certain points along the structure. Laminates varying from ⅜in to 1in in finished thickness were used, these being cut from squares and logs. The total quantity of timber in the contract amounted to approximately 1850 cubic feet. The region's chief civil engineer directed the work, the timber contractor being J. Samuel White and Co., Ltd.

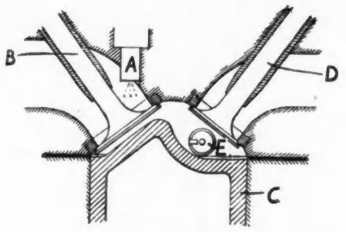
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

INTERNAL COMBUSTION ENGINES

779,978. November 21, 1955.—Fuel-Injection Spark-Ignition, Société Anonyme Andre Citroen, 117 to 167, quai de Javel, Paris, France.

The invention consists in a method of injecting fuel into a spark ignition engine comprising a cylinder, an inlet port in the cylinder, a valve to open and shut the inlet port and a fuel injection device located upstream of and in close vicinity of the inlet port, that permits advantages of direct injection into the cylinder or combustion chamber. As will be seen from the drawing, a fuel injector *A* is located in the intake duct very close to the inlet valve *B*. The piston *C* is so shaped as to form with the inner wall of the cylinder head, in the region of the exhaust valve *D*, a turbulence chamber in which the sparking plug *E* is located. The arrangement operates as follows: fuel is injected through the injector *A* at the end of the exhaust stroke, the injection beginning before the inlet valve opens and ending before the opening of the inlet valve or soon after the opening. The inlet valve *B* opens and causes the fuel to be forced into the cylinder by the combustion air, the second phase of the induction stroke consisting in introducing only pure air into the cylinder. Just before the end of the compression stroke the greater part of the heterogeneous mixture flows into the turbulence chamber in which the ignition is produced by means of the sparking plug *E*. As in the case of direct-injection systems it is also possible to associate the heterogeneous mixing effect with the turbulence, the latter being properly effected in relation to the sparking plug position, and to burn rich mixtures giving maximum power or lean mixtures which permit maximum economy and maximum thermal efficiency.—*July* 24, 1957.

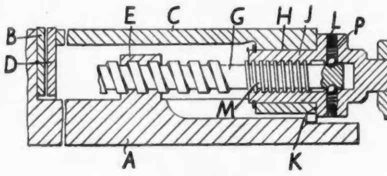


No. 779,978

WORKSHOP TOOLS AND APPLIANCES

779,153. April 7, 1954.—Vices and other Screw-Operated Mechanisms, Albert Charles Trow, 3, Highfield Road, Bexleyheath, Kent, formerly of "Ryecroft," Ryecroft Road, Otford, Kent.

The invention relates to vices and other devices in which a longitudinal force is exerted, or forced longitudinal movement of an element is produced, by the rotation of a screw member, and it has for an object to provide an improved screw mechanism for such devices which permits a fast movement to be produced by the screw for approach or return of the movable element, for example, of the movable jaw of a vice, while being capable of exerting great force when required. In the drawing a vice is shown comprising a base member *A* carrying a relatively fixed jaw *B* and a sliding member *C* carrying a relatively movable jaw *D*. As shown in the upper view, the base member *A* is provided with a quick-pitch thread nut *E* projecting from the base to engage the threads of an operating spindle *G*. The end of the sliding member *C* has a recess *H* in which is located a cap nut *J* that is formed with an annular shoulder *K* bearing against the end *L* of the member *C*. The cap nut is provided with a square or hexagon end suitable for receiving a wrench or handle. The cap nut *J* is formed with a slow-pitch thread in which are engaged the slow-pitch threads *M* at the end of the spindle *G*. Two bores *P* are located transversely of the cap nut *J* and these bores accommodate spring-loaded balls which engage recesses in the end of the spindle *G*. In order to close the vice the spindle is rotated by the handle, whereupon the quick-pitch thread will cause rapid traverse of the sliding jaw due to the spindle *G* rotating jointly with the cap nut *J* until the sliding jaw *D* clamps a workpiece against the fixed jaw *B*, whereupon resistance is encountered. Upon further rotation the resistance increases until a point is reached at which the spring-loaded balls are forced out of their recesses, whereupon the slow-pitch thread *M* comes into effect, thus allowing greater pressure to be exerted for clamping the workpiece. In practice the quick-pitch thread may have a pitch four times as great as that of the slow-pitch thread so that opening and closing of the vice will be effected at four times the speed produced by the thread employed for exercising the actual clamping force. If desired, means may be provided to ensure the re-setting of the fine thread to the normal out-of-operation condition in the cap nut when the vice is opened after use.—*July* 17, 1957.

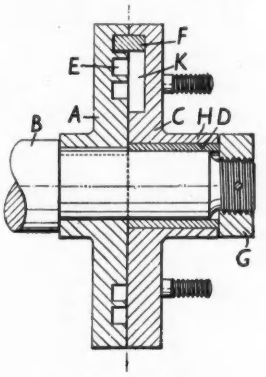


No. 779,153

ROAD TRANSPORT

778,971. April 1, 1955.—Road Vehicle Transmission Systems, William Rushworth, 1, Methuen Street, Liverpool, 15.

The invention concerns a road vehicle transmission system including a rotational lost motion connection between a driving axle and the driven wheel. By the invention a relatively simple transmission system may be used, especially on light vehicles, instead of a conventional differential gearing. It will be seen from the drawing that the rotational lost motion connection comprises a driving member *A*, keyed to a rear axle *B*, of a vehicle and a driven member *C* rotatably mounted relative to the rear axle, the driving and driven members being mounted coaxially on the axle. A bush *D* is press fitted on to the shaft *B* and the driven member *C* is a sliding fit on this bush. The driving member *A* has on one face a coaxially extending spiral track or scroll *E*, comprising a groove of rectangular cross-section, whilst the driven member *C* is rotationally coupled to a radially displaceable dog *F* engaging in the track, thereby providing a rotational lost motion connection between the two members. A nut *G* prevents the driven member *C* from sliding off the bush *D*. A wheel is mounted on a hub *H* of the driven member and secured, by nuts, on bolts. The dog *F* is accommodated in a radial groove *K* in the driven member, the groove being of rectangular cross-section and of a length coextensive with the maximum radial separation of any two parts of the spiral groove *E* intersected by a radius. The dog consists of a slug of hardened steel curved to allow for its easy passage around the sharpest curvature at the inner end of the spiral track.—*July* 17, 1957.

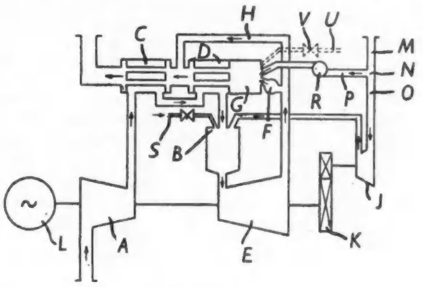


No. 778,971

GAS TURBINES

778,896. September 30, 1955.—Gas Turbine Plants, Sulzer Frères, Société Anonyme, Winterthur, Switzerland.

The invention relates to a method of heating the working medium of a gas turbine plant running at constant speed and supplied, as its main fuel, with a combustible gas of low calorific value. The amount fluctuates between a minimum and a maximum independently of the gas turbine plant and an additional fuel can be supplied. In the gas turbine plant shown in the drawing, air serving as the working medium is drawn in by a compressor *A* and delivered under pressure into a combustion chamber *B* through the secondary side of a heat exchanger consisting of two sections *C* and *D*. The heated working medium is thereupon expanded in a turbine *E*. Part of the expanded working medium is then forced by a fan *F* into another combustion chamber *G*, which communicates with the primary side of the section *D* of the heat exchanger, and the rest is conducted through a pipe *H* to the primary side of the section *C* of the heat exchanger, by-passing the section *D*, and rejoins the working medium which passed through the primary side of the section. After passing through the primary side of the section *C* the working medium is discharged into the atmosphere. The turbine *E* drives the air compressor *A*, a combustible gas compressor *J* through gearing *K*, and a constant-speed electric generator *L*, which feeds the useful output of the plant into an electric network. The combustible gas, of low calorific value. is supplied through a pipe *M*. From a junction *N* one branch pipe *O* leads into the combustion chamber *B* before the turbine, and a second branch pipe *P* leads into the combustion chamber *G* on the primary side of the heat exchanger. In the first branch pipe *O* there is the combustible gas compressor *J*. which is driven at constant speed and continually delivers a constant amount of combustible gas into the combustion chamber *B*. The rest of the combustible gas is forced by a fan *R* into the combustion chamber *G*. Additional fuel for compensating any deficiency in heat energy can be introduced into the combustion chamber *B* through a pipe *S*, the amount introduced being regulated by a valve *T*. It is also possible to introduce additional fuel through a pipe *U* into the combustion chamber *G* and to regulate the amount so introduced by a valve *V*. —*July* 10, 1957.

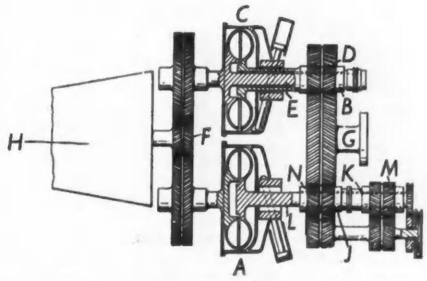


No. 778,896

POWER TRANSMISSION

779,893. December 18, 1953. Power Transmission Mechanisms, Harold Sinclair, Magnolia House, 4, Clarence Crescent, Windsor, Berkshire.

According to the invention, there is provided a geared power transmission specially suitable for propeller drives, the mechanism comprising first and second parallel power paths between a driving member and a driven member, the first path being wholly mechanical and providing a constant speed ratio between the driving and driven members and the second path including a slip coupling of the hydraulic turbo or electromagnetic type, the input and output shafts of which are drivably coupled to the driving and driven members, respectively, so as to have constant speed ratios such that for a given speed of the driving member the input shaft rotates at a suitably higher speed than the output shaft to conform with the slip that is necessary in the coupling when transmitting the desired proportion of the power. In the mechanism shown in the drawing, a single hydraulic turbo-coupling *A* is included in the second power path and with the clutch *B* there is arranged in parallel a turbo-coupling *C* connected to pinion *D* which serves as an alternative means of clutching the input shaft *E* to the pinion *D*, so as to establish another hydraulic power path between pinion *F* and shaft *G*. For ahead drive at full power, turbo-coupling *A* has its working circuit filled, turbo-coupling *C* has its working circuit empty, and the clutch *B* is engaged. The power is divided between the two paths and the total slip loss at full power is about 1 per cent, assuming that the slip in turbo-coupling *A* would be about 2 per cent if it were transmitting the whole of the power delivered by the prime mover *H*. In this case the clutches *J* and *K* serve to clutch the output shaft *L* of coupling *A* alternatively to the ahead pinion *N* or to the pinion *M*. For manœuvring, the output shaft *L* is clutched



No. 779,893

to pinion *M* and ahead or reverse drive is obtained selectively by alternatively filling the working circuits of couplings *C* and *A*, clutch *B* being disengaged. In neutral drive, the working circuits of both the turbo-couplings are partly filled and hence the torques are in opposition and there is no drive transmitted to the propeller shaft *G*. For ahead drive at full power, the output shaft *L* is clutched to the ahead pinion *N*, clutch *B* is engaged, and the working circuits of turbo-couplings *A* and *C* are full and empty, respectively. It will be seen that the function of clutch *B* when engaged is to by-pass the turbo-coupling *C*, the latter being capable of coming into operation only when clutch *B* is disengaged. If preferred, therefore, the clutch *B* and turbo-coupling *C* may be provided in entirely separate power paths which are alternatively effective to provide mechanical transmission through the clutch or hydraulic transmission through the turbo-coupling *C*.—*July* 24, 1957.

Technical Reports

The Reduction and Presentation of Experimental Results. B.S. 2846 : 1957. By J. T. Richardson, B.Sc. Price 10s.—This book points out that uniformity of procedure in presenting experimental results is essential, both in summarising and comparing results obtained in the many determinations made in engineering production and in other kinds of scientific and technological investigation. It gives guidance on a wide variety of experiments, e.g. in the laboratory or the factory, in research or in workshop production, in small or large-scale observations, or in a series of repetitive tests such as those made for the quality control of products at different stages of manufacture.

Of particular interest is a chapter on frequency distribution—a subject which deals with the grouping and sorting of observations, and is useful in presenting the results of large numbers of observations in a condensed form. The evaluation and use of the quantities " arithmetic mean " and " standard deviation " for presenting in brief form the results of an experiment are illustrated, and detailed examples relate to such widely divergent subjects as the compression strength of concrete cubes, the phosphorus pentoxide content of a fertiliser, and the breaking strengths of cotton fabric strips and of hard-drawn copper wire.

Another section of the book deals with the reliability of the results of an experiment expressed in terms of " confidence limits," i.e. the limits within which it is estimated that the true values of the arithmetic mean and the standard deviation lie, when associated with a stated probability. An application of the recommended form of presentation of experimental results is described in relation to the repetitive tests necessary for the control of the quality of products during manufacture. The use of control chart techniques is briefly summarised and illustrated with examples.

Méthodes d'Exploration Dynamique et Thermique et Etude de la Couche-Limite Laminaire Compressible de la Plaque Plane. By Max Plan. Publications Scientifiques et Techniques du Ministère de l'Air, No. 331. Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price F.fr.1500.—In a systematic study, the measurement of local temperatures and velocities, as well as their fluctuations, was investigated for the case of a compressible boundary layer. The dynamic characteristics were determined by the extrapolation of measurements affected by probes of decreasing size with circular ends, which were found to be more suitable than those with flat ends hitherto in use. Various designs of thermal probes were tried out, the simplest designs proving the best. Although the method of extrapolation could no longer be applied, this fact did not exclude the taking of accurate measurements. The behaviour of the laminar boundary layer is strongly influenced by the shock wave caused by the leading edge of the models, the thickness of which is necessarily small. With thicknesses of the order of 10^{-3}mm, the flow characteristics agree well with the "idealised " theories which assume an infinitely thin plane without disturbance at the leading edge. Larger thicknesses cause an increase in the boundary layer, still sensibly in agreement with the " ideal " case. The local coefficient of friction is less, but the total resistance is larger than the ideal value. Temperature profiles are still more distorted than the velocity profiles, in particular the heat transfer coefficient increases. As the effect of shock waves upon the compressible boundary layer is not amenable to exact calculation, an approximate treatment is given here which gives results in good agreement with present and previous experiments.

Contribution a l'Etude de la Convection Forcée de la Chaleur sur des Parois Rugueuses. By G. Brunello. Publications Scientifiques et Techniques du Ministère de l'Air, No. 332. Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price F.fr.1350.—With the object of extending knowledge concerning the effect of surface asperities upon heat transfer by forced convection, Monsieur Brunello carried out a series of researches at the Bellevue Laboratories of C.N.R.S., part of the work being in collaboration with Mademoiselle M. Vernotte (Madame Pollet). The first part of the report concerns the convection from rough cylindrical surfaces placed at right angles to a gas stream. With cylinders having six values of relative roughness, and also smooth cylinders, and temperature differences up to 30 deg. Cent., a range of Reynold's numbers between 6000 and 14,000 was investigated. In the second part, a new method was used to determine the heat flow between a wall and a moving fluid, based on temperature and speed measurements inside the boundary layer. Lastly, a study was made of the heat transfer and friction of plane rough surfaces placed in parallel with an airstream, for a range of Reynold's numbers of 2×10^5 to $1{\cdot}9\times10^6$. The test surfaces were made of sintered bronze.

Market Research Methods in Europe (*Project No.* 261). By C. Kapferer. Published by the European Productivity Agency of the O.E.E.C. Paris : The Organisation for European Economic Co-operation, 2, rue André-Pascal, Paris (16e). Price 9s.—The aim of E.P.A. Project No. 261 was to report on the use of market research in Western Europe, and to examine its possibilities in the drive for increased productivity. The report was to offer recommendations, principally to the industrial manager, and it was not intended that market research techniques should be discussed in detail except when problems and case histories made this necessary.

Launches and Trial Trips

KORAKI, cargo ship ; built by Alexander Stephen and Sons, Ltd., for the Union Steam Ship Company of New Zealand, Ltd.; length 325ft, breadth 51ft, depth 26ft, deadweight 5300 tons ; three hatches, twelve derricks, MacGregor hatch covers, electric winches ; Stephen-Sulzer single-acting diesel engine, six cylinders, 600mm diameter by 1040mm stroke, 2410 b.h.p. at 128 r.p.m. Launch, June 12.

DONA EDIE, closed shelter deck cargo ship ; built by William Doxford and Sons (Shipbuilders), Ltd., for the Compania Panamena Europea Navegacion, Limitada ; length between perpendiculars 470ft, breadth moulded 67ft, depth moulded 40ft 8in, deadweight 12,500 tons (open shelter deck), 14,670 tons (closed shelter deck), speed 13½ knots ; five holds, one 25-ton, six 10-ton, six 5-ton derricks, steam winches ; Doxford four-cylinder opposed piston oil engine. Launch, June 12.

LLANISHEN, oil tanker ; built at Wallsend by Swan, Hunter and Wigham Richardson, Ltd., for E.T.R. Tankers, Ltd.; length between perpendiculars 635ft, breadth moulded 84ft 3in, depth moulded 46ft 3in, deadweight 31,000 tons, load draught 34ft 6in, service speed 16½ knots ; thirty cargo oil tanks, one main cargo pump room, four 1160 tons per hour turbine-driven cargo pumps, three stripping pumps ; two 550kW turbo-alternators, one 150kW diesel-driven alternator ; one set of Wallsend double reduction geared compound turbines, 14,500 maximum s.h.p. at 109 propeller r.p.m., steam supplied at 600 lb per square inch and 850 deg. Fah. by two Babcock and Wilcox boilers. Launch, June 12.

AFGHANISTAN, ore carrier ; built at Govan by Harland and Wolff, Ltd., for the Hindustan Steam Shipping Company, Ltd.; length between perpendiculars 485ft, breadth moulded 68ft 9in, depth moulded 36ft 3in, deadweight 15,800 tons, service speed 11½ knots ; two centre ore holds, each having three hatches; wing ballast tanks, electric deck machinery ; three 220kW diesel-driven generators, one 40kW diesel-driven emergency generator ; Harland and Wolff two-stroke, single acting, opposed piston diesel engine, four cylinders, 620mm diameter by 1870mm combined stroke, 118 r.p.m. Trial, June 20.

Advanced Engineering Courses

High-Voltage Engineering. SOUTH EAST LONDON TECHNICAL COLLEGE, Lewisham Way, S.E.4. A course of about fourteen lectures and twelve practical laboratory periods, in two parts : Part A, High-Voltage Laboratory Techniques ; Part B, Insulating Material Characteristics. Tuesday evenings, 6.45 to 9.15 p.m., commencing October 8. Fee £2 10s.

An Introduction to Nuclear Physics for Engineers. SOUTH EAST LONDON TECHNICAL COLLEGE, Lewisham Way, S.E.4. A course of six lectures, Tuesday evenings, 6.45 to 9.15 p.m., commencing October 1. Fee 10s.

Transistor Physics and Transistor Applications. SOUTH EAST LONDON TECHNICAL COLLEGE, Lewisham Way, S.E.4. A course of eight lectures, Wednesday evenings, 7 to 9 p.m., commencing October 23. Fee £1.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ENGINEERS' GUILD

Fri., Sept. 20.—S. WALES AND MONMOUTHSHIRE BRANCH : Old Arcade Inn, Church Street, Cardiff, Luncheon, 12.45 p.m.

Thurs., Sept. 26.—METROPOLITAN BRANCH : Caxton Hall, Caxton Street, Westminster, London, S.W.1, Annual General Meeting, Discussion on " The Aims and Future Policy of the Guild," 6 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Sept. 3.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, " Maximum Demand and Power Factor and their Effect on the Electricity Tariff," T. A. Williams, 7 p.m. ★ EDINBURGH BRANCH : 25, Charlotte Square, Edinburgh, Members' Evening, 7 p.m.

Wed., Sept. 4.—LEICESTER BRANCH : Bell Hotel, Leicester, " The Painting of Buildings," R. Woodwards, 7 p.m.

Mon., Sept. 9.—DUNDEE BRANCH : Mathers Hotel, Dundee, " Variable-Speed Drives with Voltage Regulation Equipment," 7.30 p.m. ★ MERSEYSIDE AND N. WALES BRANCH : The Blossoms, City Road, Chester, " The Cost Accountant and the Plant Engineer," R. G. Hall and B. J. Willson, 7.15 p.m.

Tues., Sept. 10.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, Chairman's " At Home," 7.15 p.m.

Wed., Sept. 11.—W. BRANCH : Grand Hotel, Bristol, " Fire Prevention in Industrial Buildings," 7.15 p.m.

Thurs., Sept. 12.—GLASGOW BRANCH : Scottish Building Centre, Glasgow, " The Design and Application of Rotary and Reciprocating Air Compressors," W. Scott, 7.15 p.m. ★ N.E. BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, " Internal Combustion Engines as Applicable to Plant Engineering," Norman Parry, 7 p.m.

Tues., Sept. 17.—BIRMINGHAM BRANCH : Hotel Leofric, Coventry, " Titanium as a Material of Construction in the Chemical Industry," K. W. J. Bowen, 7.30 p.m.

Wed., Sept. 18.—KENT BRANCH : King's Head Hotel, High Street, Rochester, Ladies' Film Evening, 7 p.m.

Thurs., Sept. 19.—BLACKBURN BRANCH : Golden Lion Hotel, Blackburn, Joint Meeting with Institute of Fuel, " Fuel and Power Position in the United Kingdom," Rear-Admiral Sir Sidney Frew, 7.30 p.m.

Tues., Sept. 24.—GLASGOW BRANCH : Scottish Building Centre, 425–427, Sauchiehall Street, Glasgow, Joint Meeting with the Institution of Heating and Ventilating Engineers, " Steam," and " Combustion and the Chain Grate Stoker," 7.15 p.m. ★ S. WALES BRANCH : South Wales Engineers' Institute, Park Place, Cardiff, " Metal Degreasing by Trichloroethylene," and " Metal Pretreatment in Industry," 7.15 p.m.

Thurs., Sept. 26.—SHEFFIELD AND DISTRICT BRANCH : Grand Hotel, Sheffield, " The Design of Rolling Mills, with particular reference to Hot and Cold Ferrous Mills," M. Langen, 7.30 p.m.

Fri., Sept. 27.—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, " Some Principles of Radiant Heating," P. A. Coles, 7.30 p.m.

Mon., Sept. 30.—W. AND E. YORKSHIRE BRANCH : Leeds University, " The Safe Use of Electricity," J. J. Emerson, 7.30 p.m.

INSTITUTE OF FUEL

Wed., Oct. 9.—Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, Symposium on " Flames and Industry," 10 a.m.

INSTITUTE OF METALS

Mon. to Fri., Sept. 16 *to* 20.—Forty-ninth Annual Autumn Meeting, 1957, to be held in Glasgow.

INSTITUTE OF THE MOTOR INDUSTRY

Sat. to Sat., Aug. 24 *to* 31.—St. Catharine's College, Cambridge, Eleventh Annual Summer School.

INSTITUTE OF PETROLEUM

Wed., Sept. 4.—26, Portland Place, London, W.1, " Some Developments in Marine Drilling Foundations," A. Kranendonk, 5.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Sept. 9.—N.E. BRANCH : Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, Chairman's Address, Informal Discussion on Branch Affairs, 7.15 p.m.

Mon., Oct. 14.—N.E. BRANCH : Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, " Building Structures," G. Gladstone, 7.15 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Sat., Aug. 31.—S. BRANCH : Whole-day visit to the pumping stations of the Mid-Wessex Water Company, Frimley, Surrey.

Sat., Sept. 14.—SOUTHERN BRANCH : Whole-day visit to the Greenham Common base of the United States Air Force, Newbury, Berks, 10 a.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., Sept. 4.—COVENTRY GRADUATE SECTION : Visit to British Piston Ring Company, " Changing from Batch to Flow Production," H. C. Blackford, 7.15 p.m.

Wed., Sept. 18.—BIRMINGHAM SECTION : College of Technology, Gosta Green, Birmingham, 4, Film Evening, 7 p.m. ★ WOLVERHAMPTON GRADUATE SECTION : Wolverhampton and Staffs College of Technology, Wulfruna Street, Wolverhampton, " Nimonic Presswork," J. A. Grainger, 7.30 p.m.

Tues., Sept. 24.—OXFORD SECTION : Town Hall, Oxford, " Transfer Pressing," 7.30 p.m.

Wed., Sept. 25.—SHREWSBURY SECTION : Shrewsbury Technical College, Shrewsbury, " British Clock and Watch Production," R. Lenoir, 7.30 p.m.

Thurs., Sept. 26.—NORWICH SECTION : Norwich City College, Ipswich Road, Norwich, " S.G. Iron—A Versatile Engineering Metal," W. W. Braidwood, 7 p.m.

Fri., Sept. 27.—LEICESTER SECTION : Grand Hotel, Leicester, " Work Measurement and Its Uses for Management," W. Hewett, 7 p.m.

IRON AND STEEL INSTITUTE

Wed. and Thurs., Sept. 25 *and* 26.—IRON AND STEEL ENGINEERS' GROUP : Church House, Westminster, London, S.W.1, " Air Pollution in the Iron and Steel Industry."

MANCHESTER GEOLOGICAL AND MINING SOCIETY

Thurs., Oct. 10.—Mining and Technical College, Wigan, Annual General Meeting, 3.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Fri., Sept. 13.—FORTY-FIFTH WILBUR WRIGHT MEMORIAL LECTURE : Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, " Advanced Education and Academic Research in Aeronautics," Clark B. Millikan, 6 p.m.

SOCIETY FOR WATER TREATMENT AND EXAMINATION

Wed. to Fri., Oct. 2 *to* 4.—Palace Hotel, Southend-on-Sea, Autumn Meeting.

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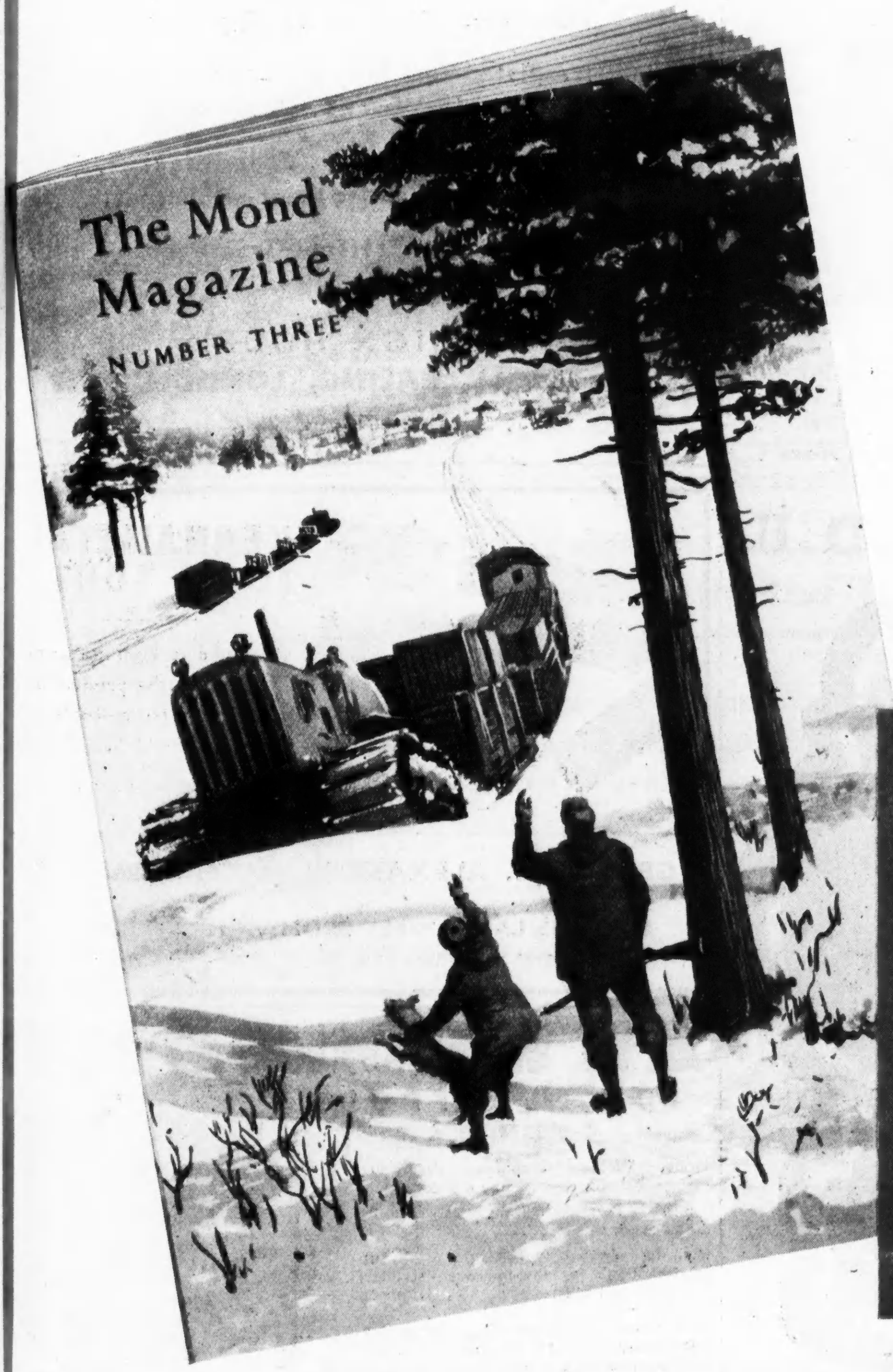

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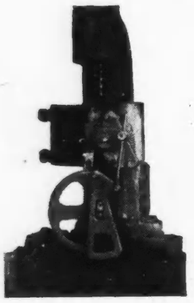

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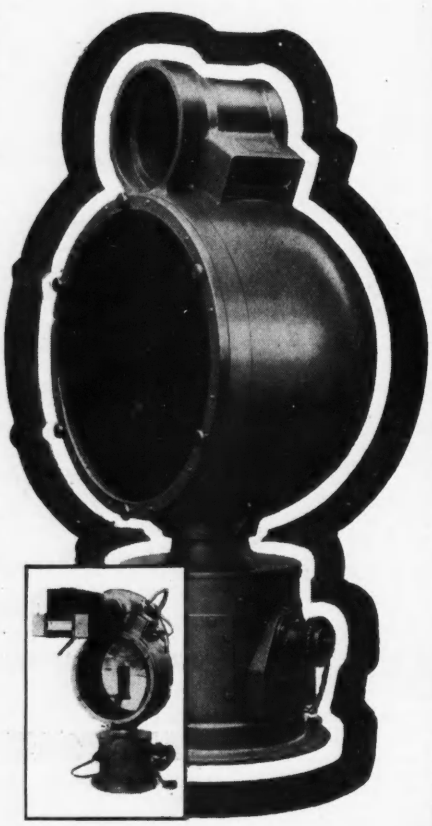

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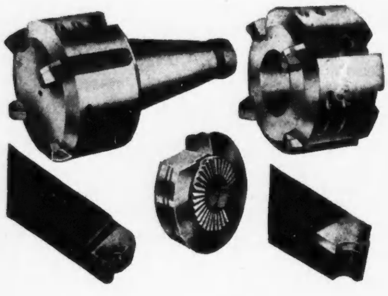

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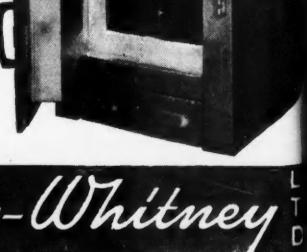

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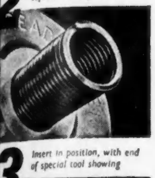
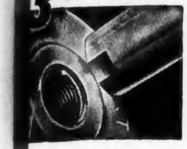


3 Insert in position, with end of special tool showing



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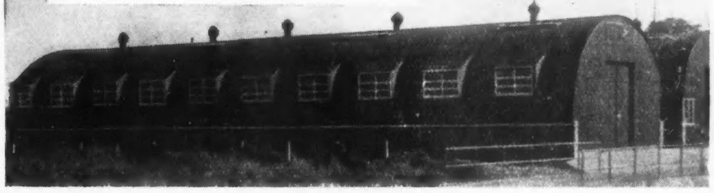

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The bottom photograph – by courtesy of Stafford Allen & Sons Ltd., Long Melford–is of two Nissen Type sheds, size 120′ × 30′.

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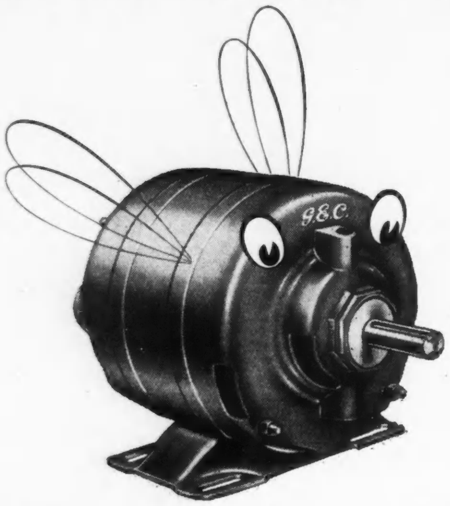

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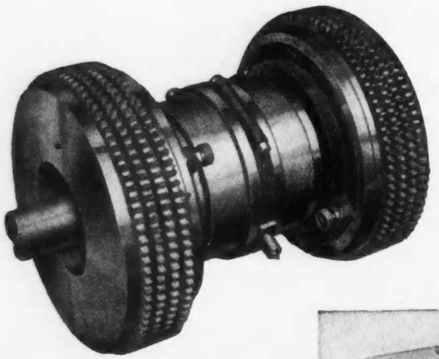

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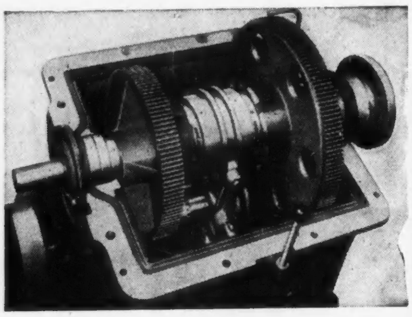

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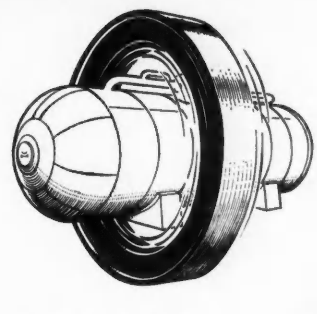

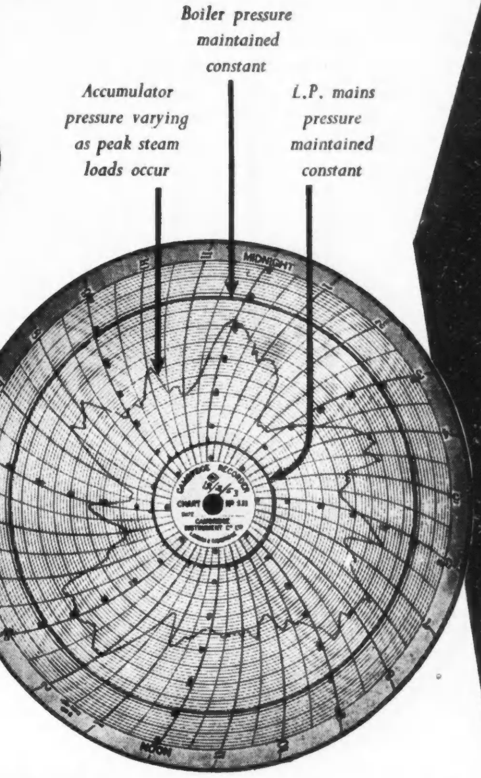
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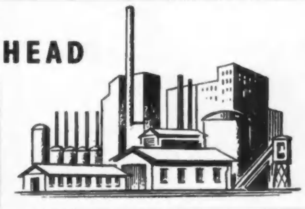

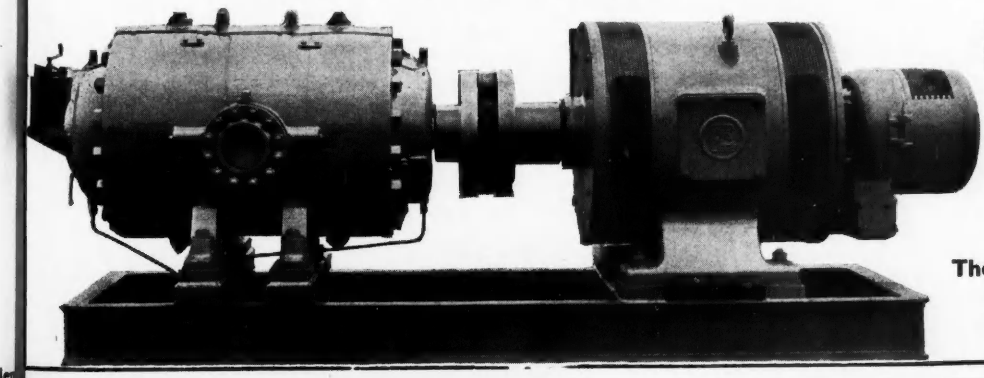

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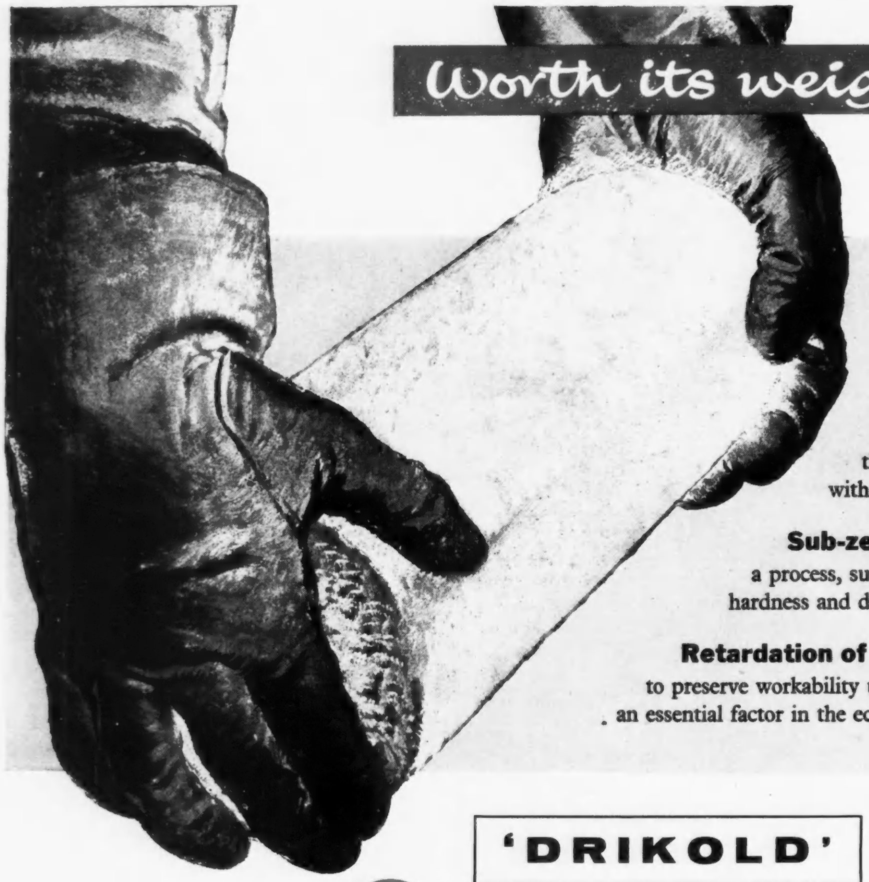

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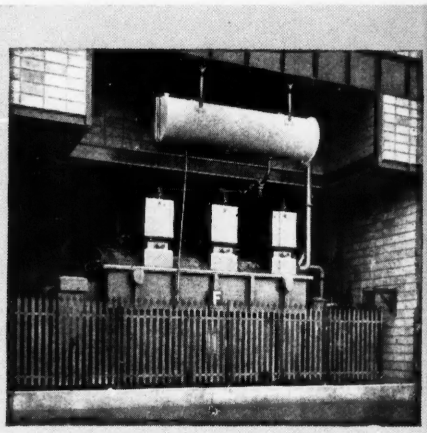

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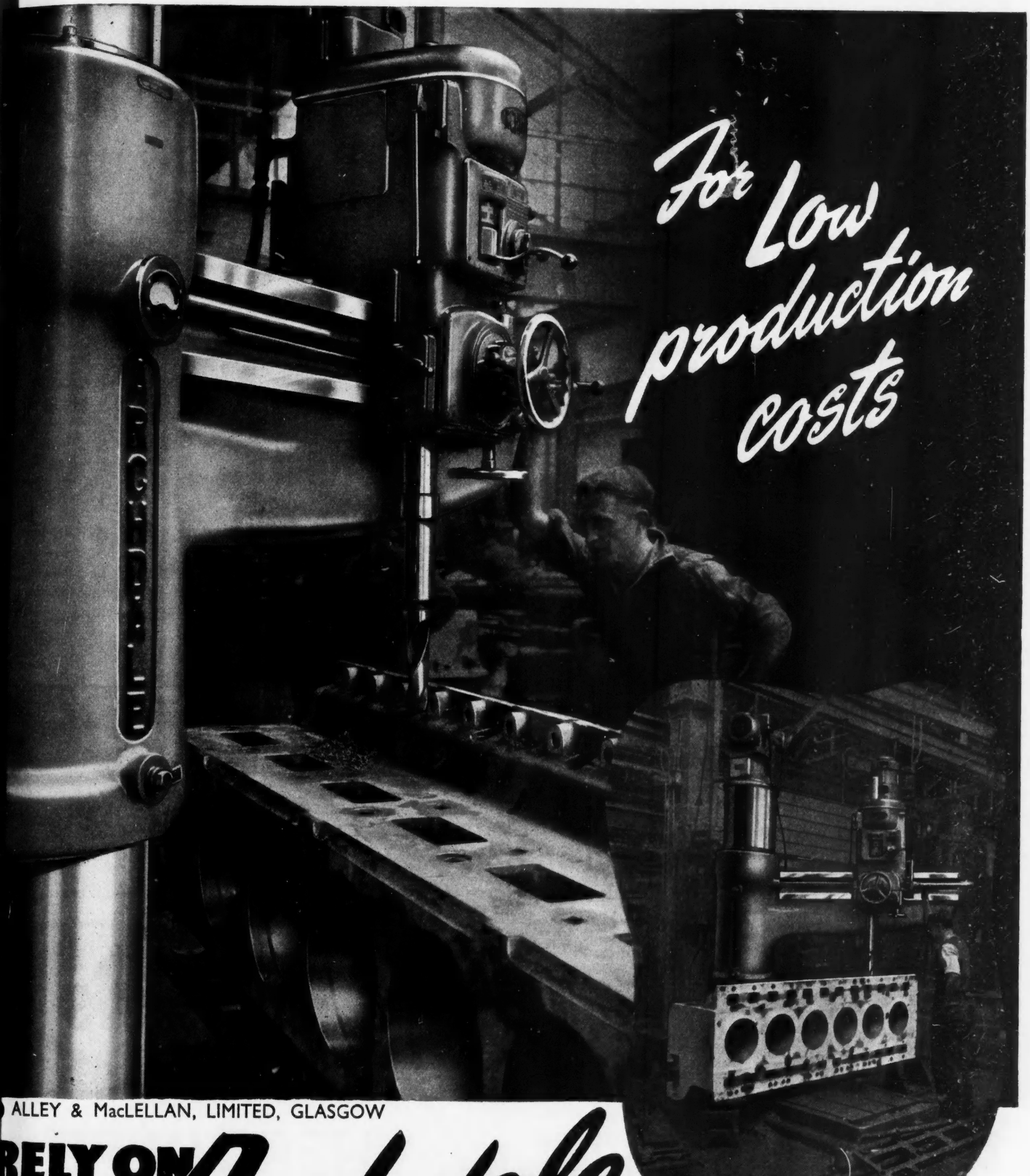

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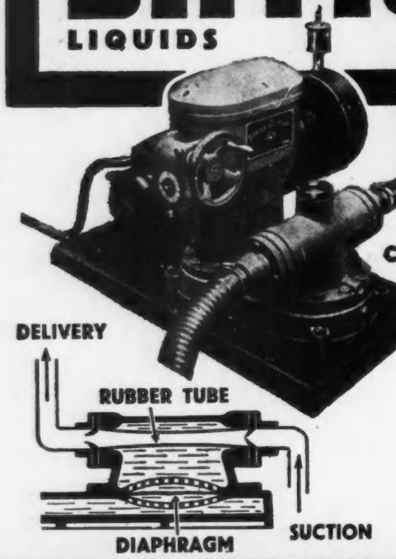

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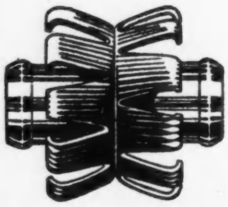

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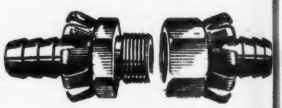

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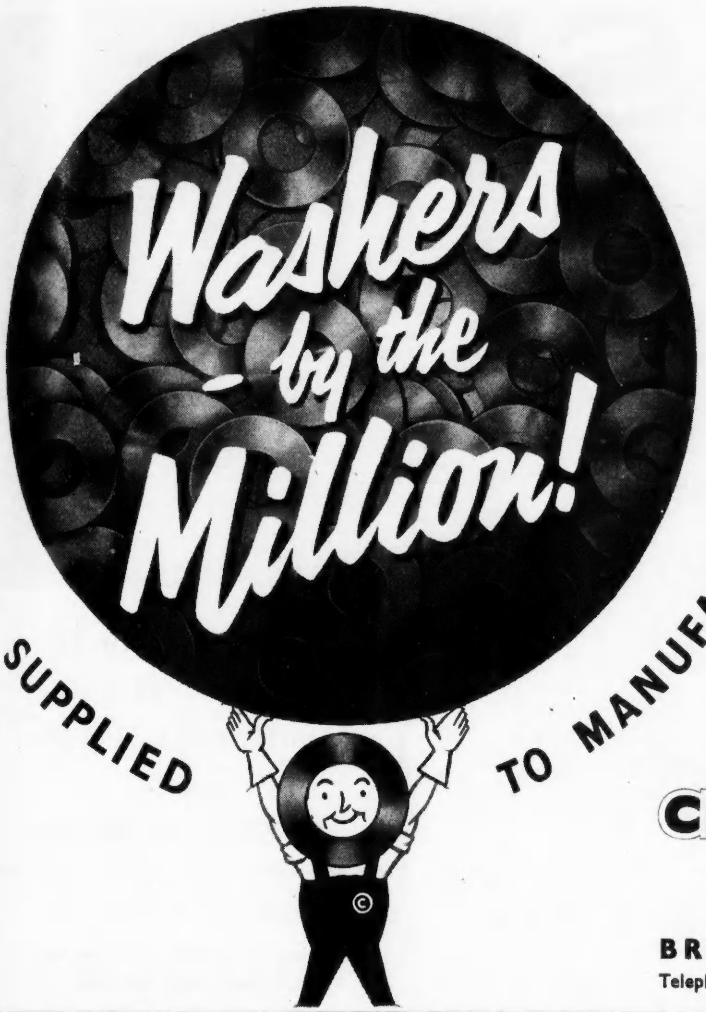
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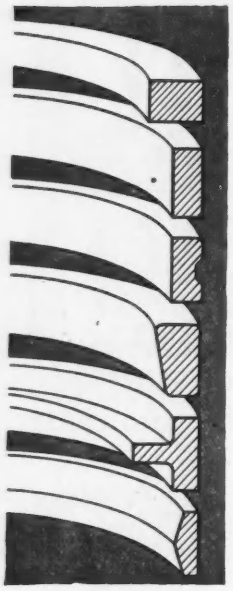

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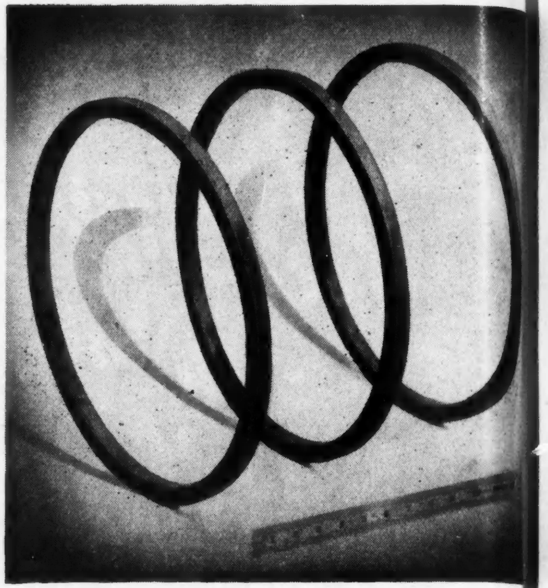

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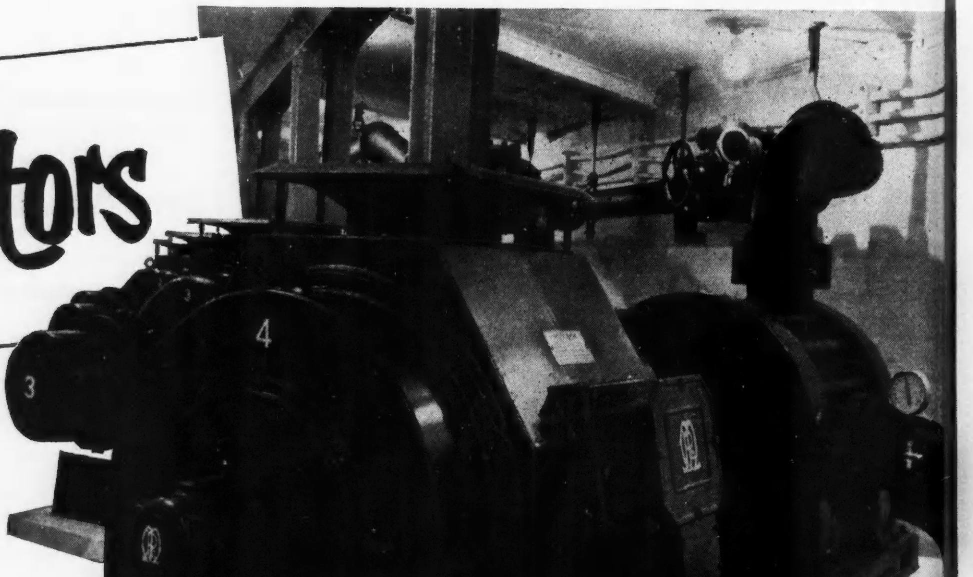

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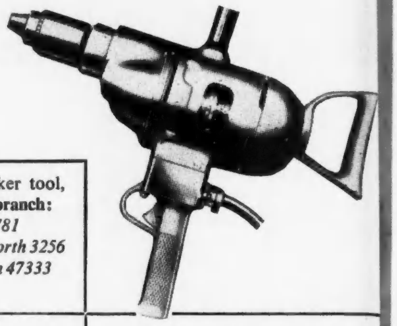

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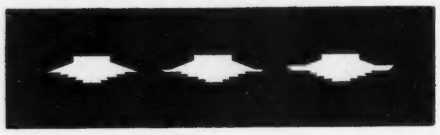

Main types, A, B and C.

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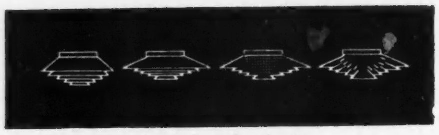

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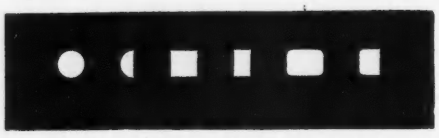

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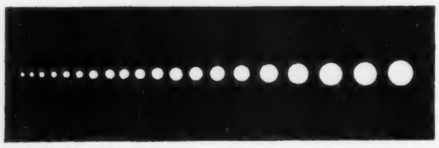

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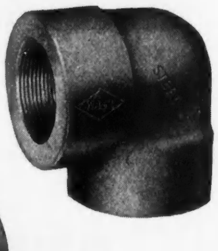

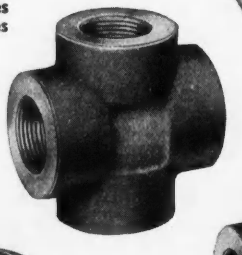

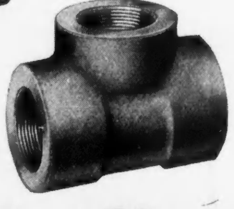

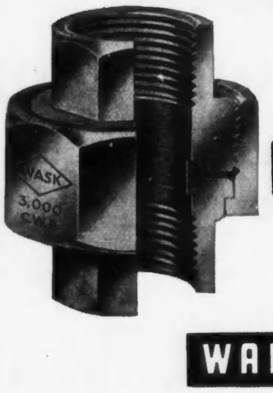

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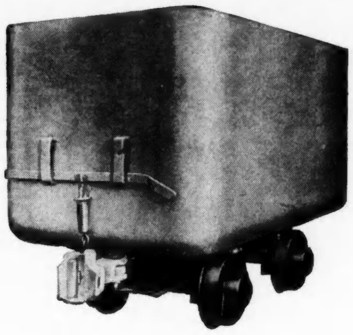

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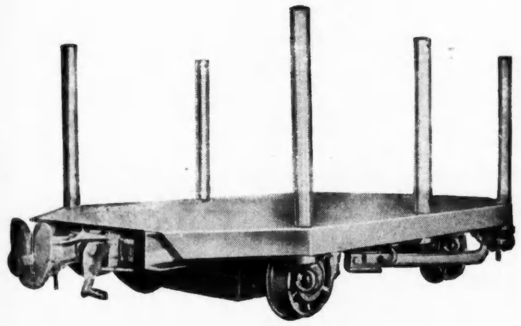

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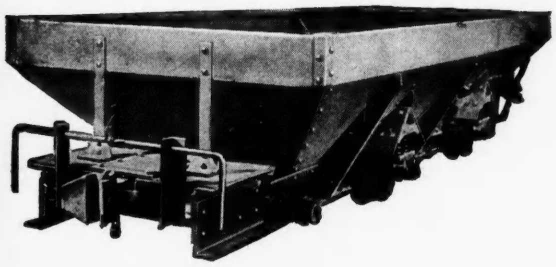

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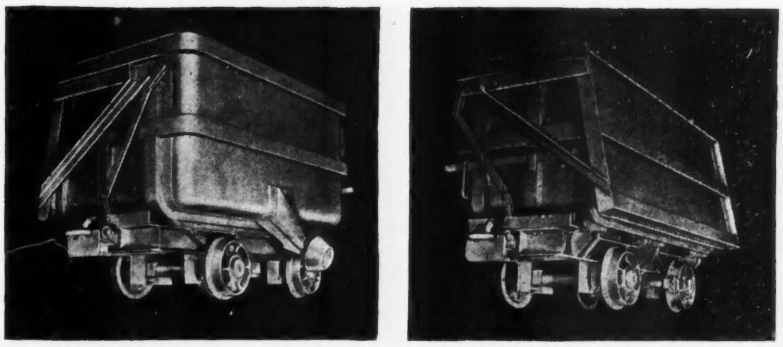

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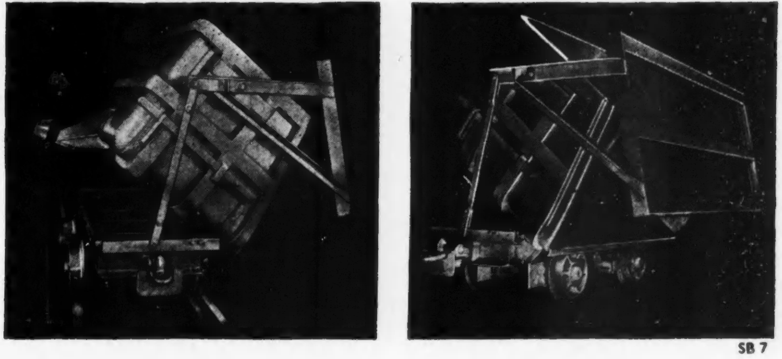

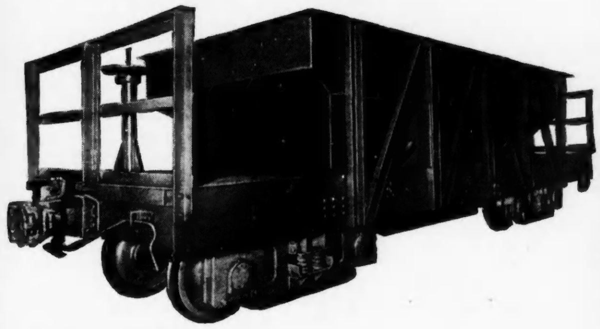

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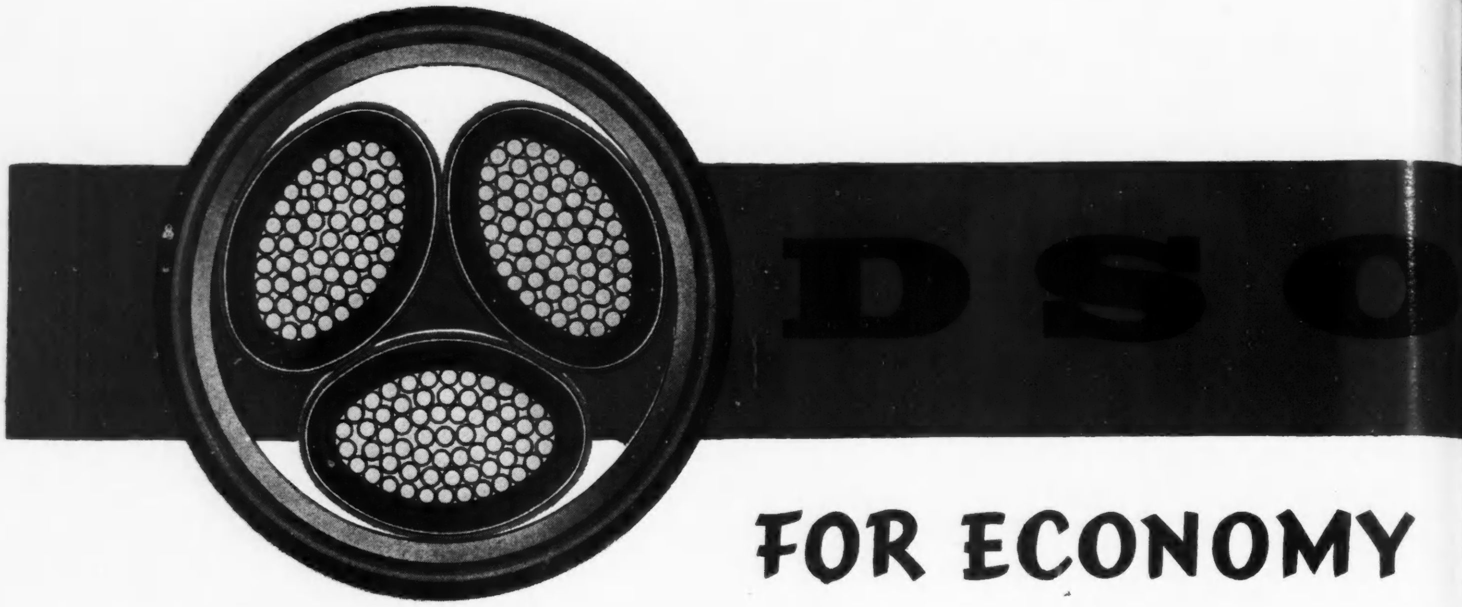

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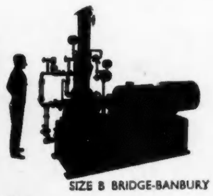

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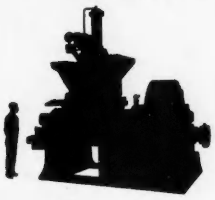

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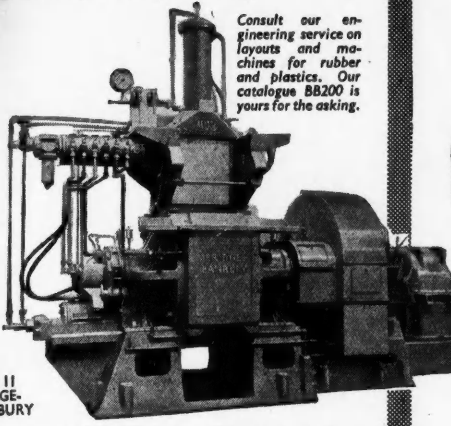

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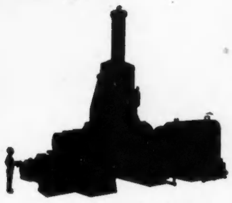

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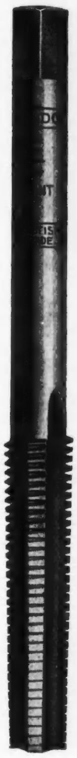

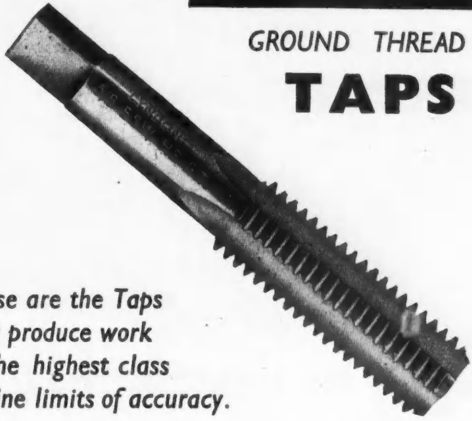

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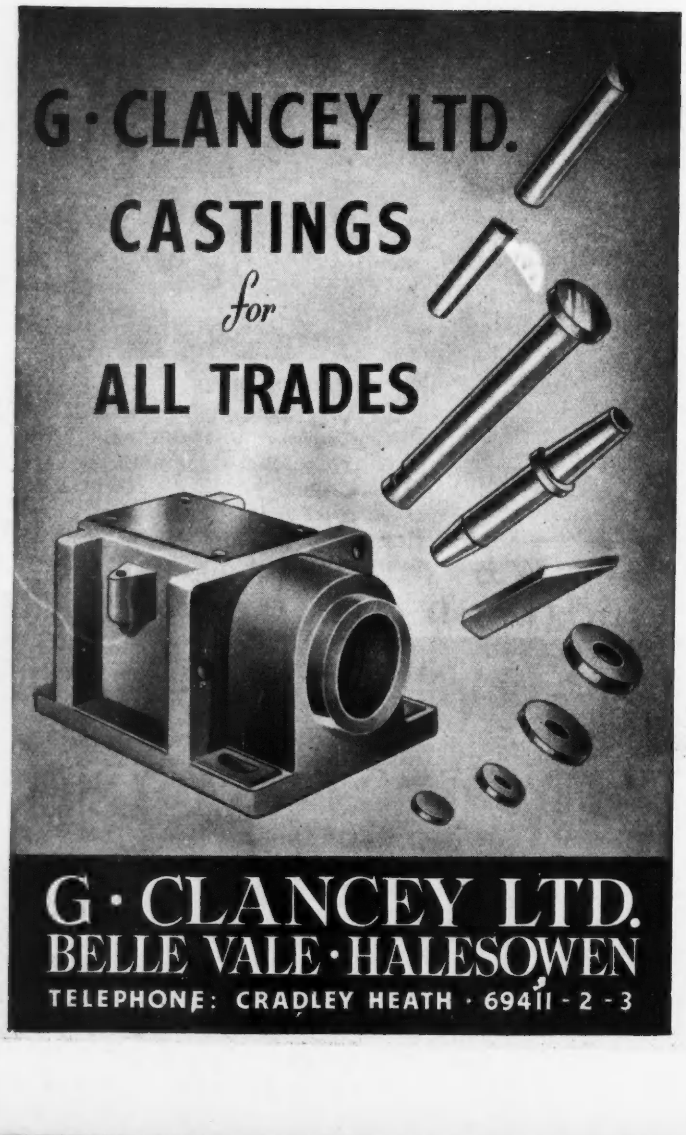

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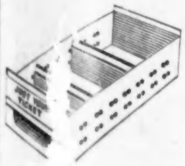

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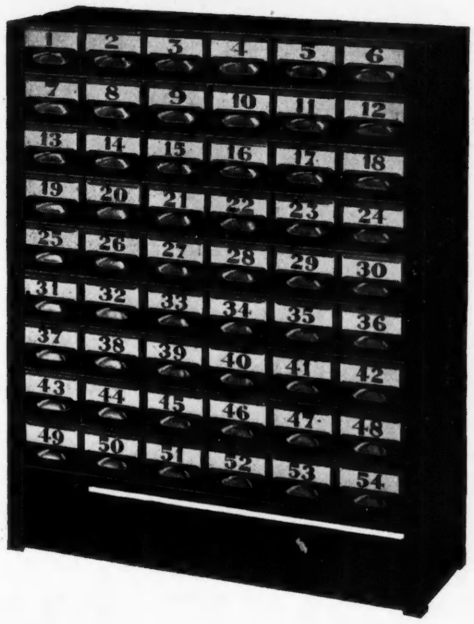

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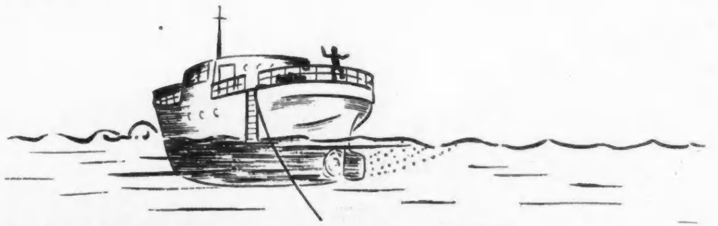

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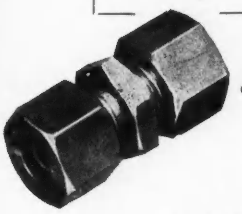

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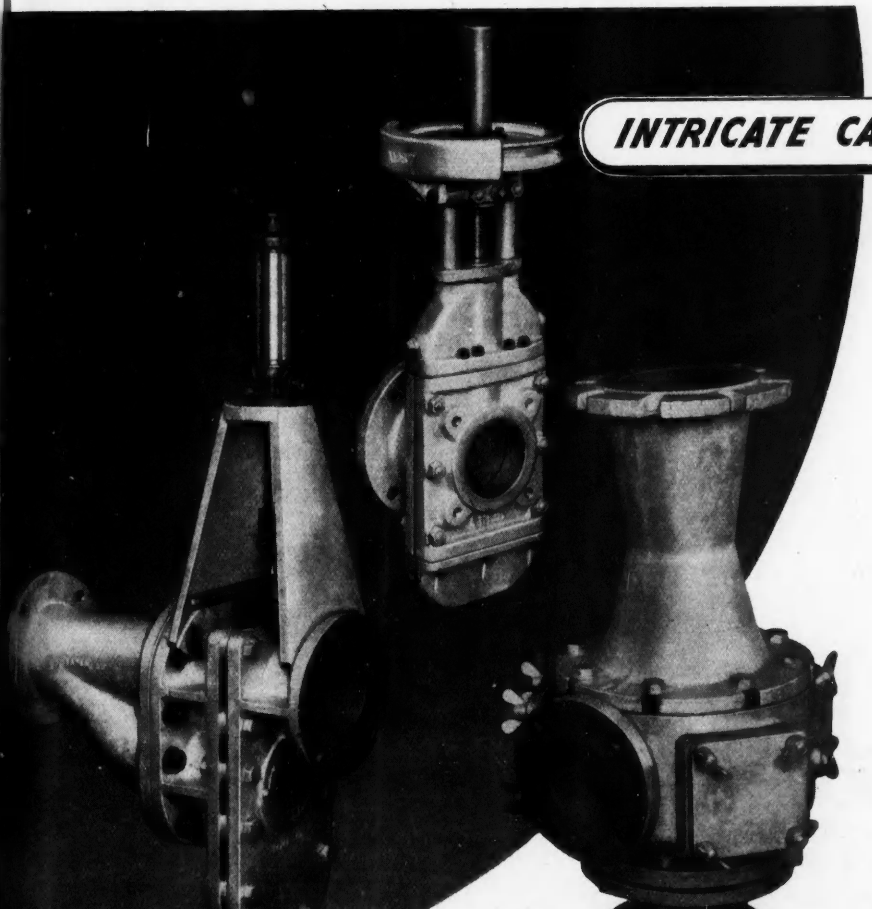

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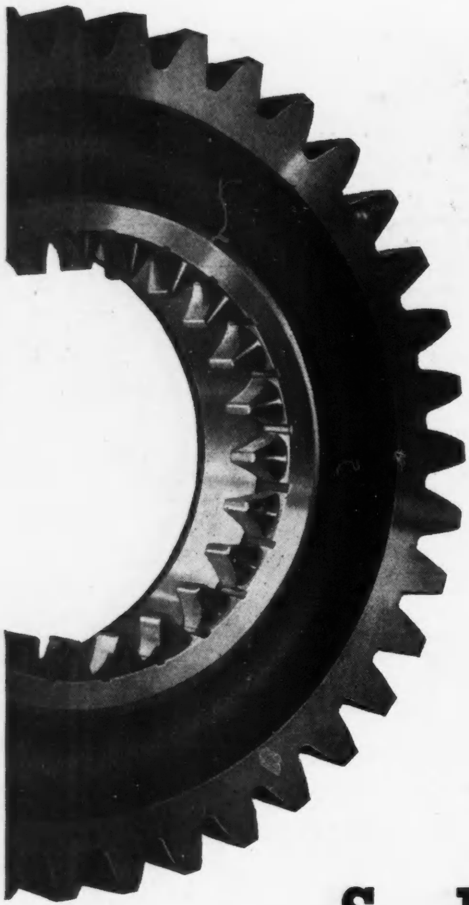

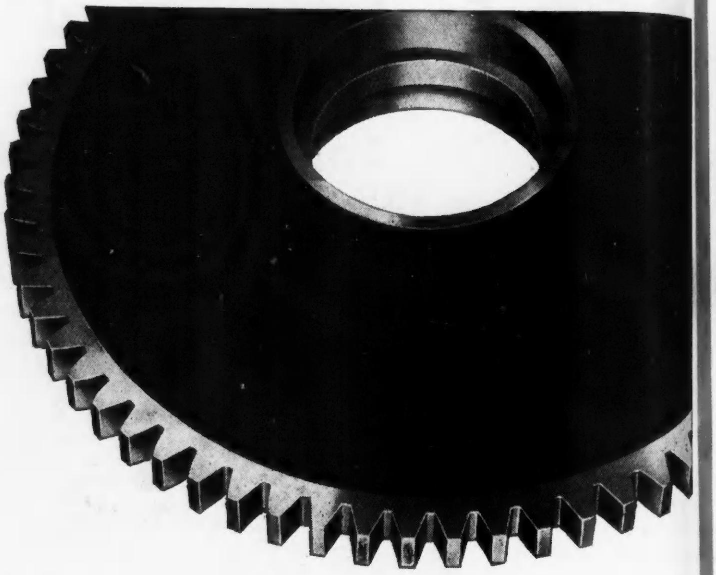

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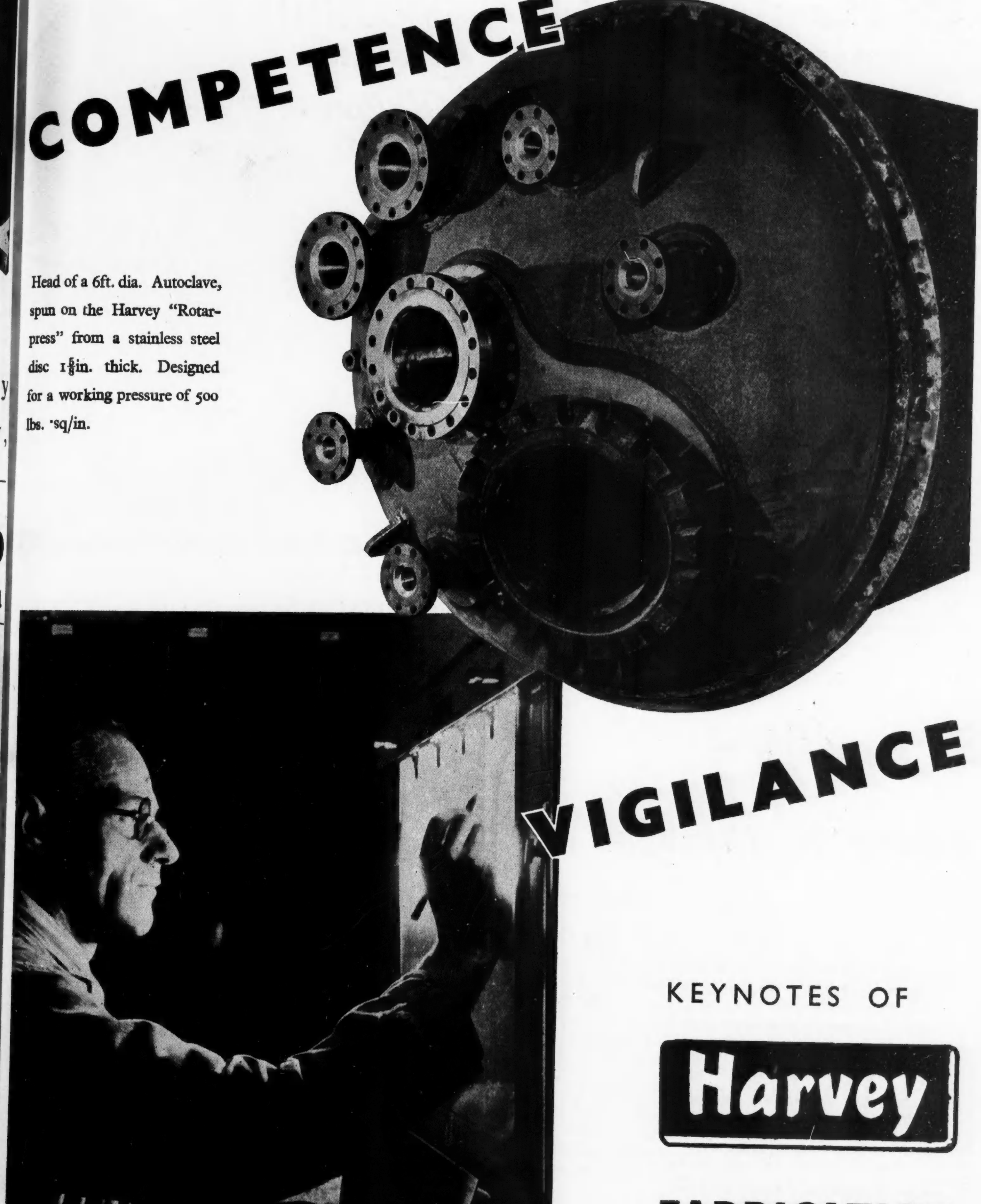

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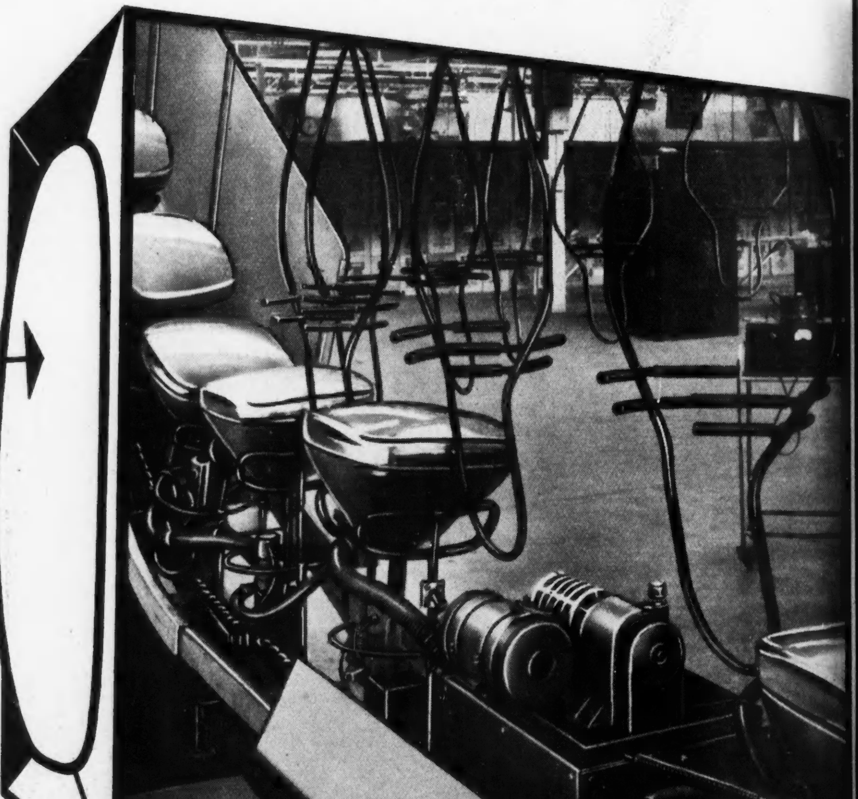

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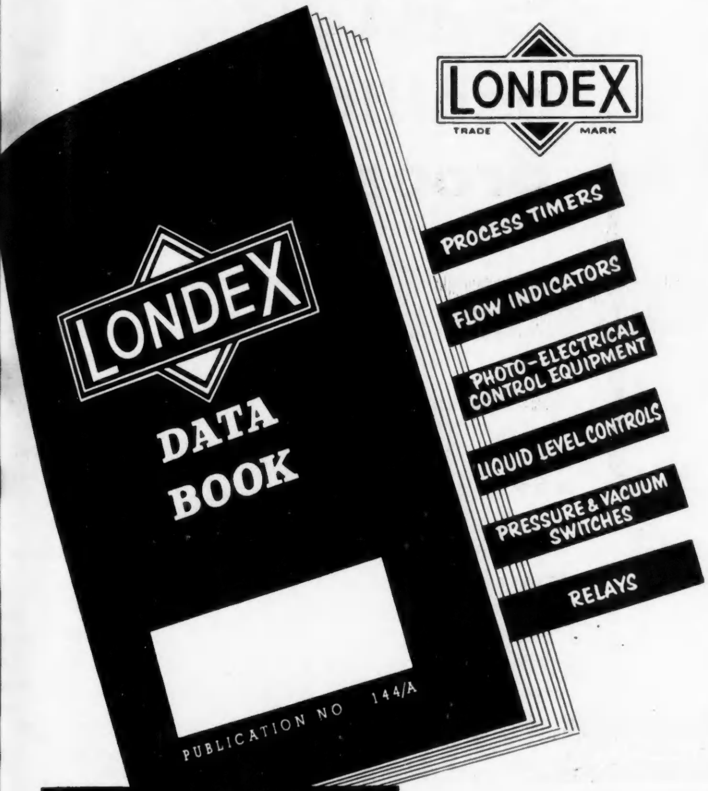
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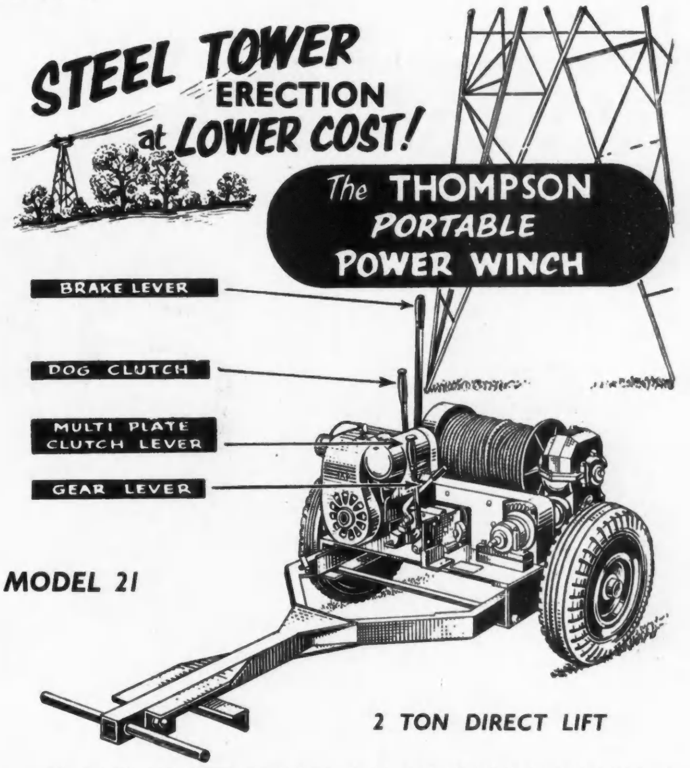
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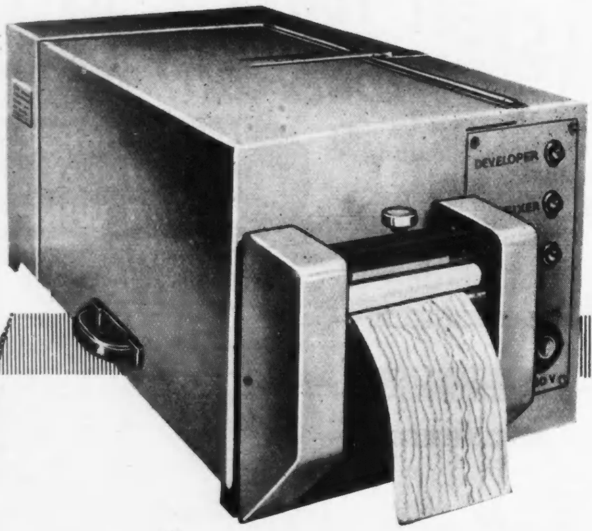

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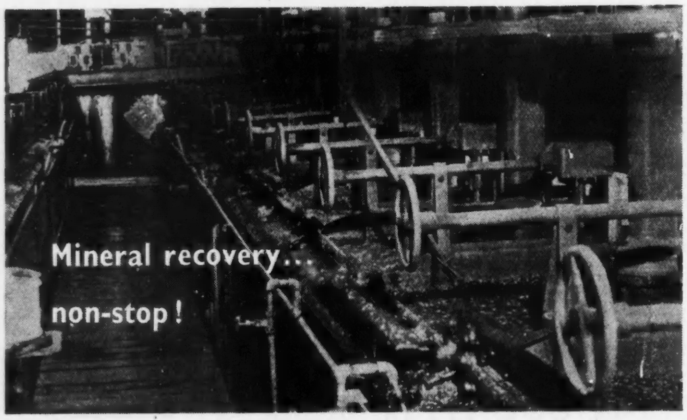

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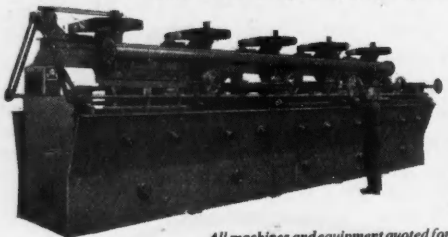

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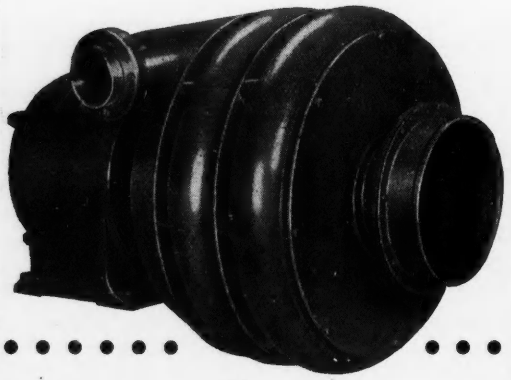

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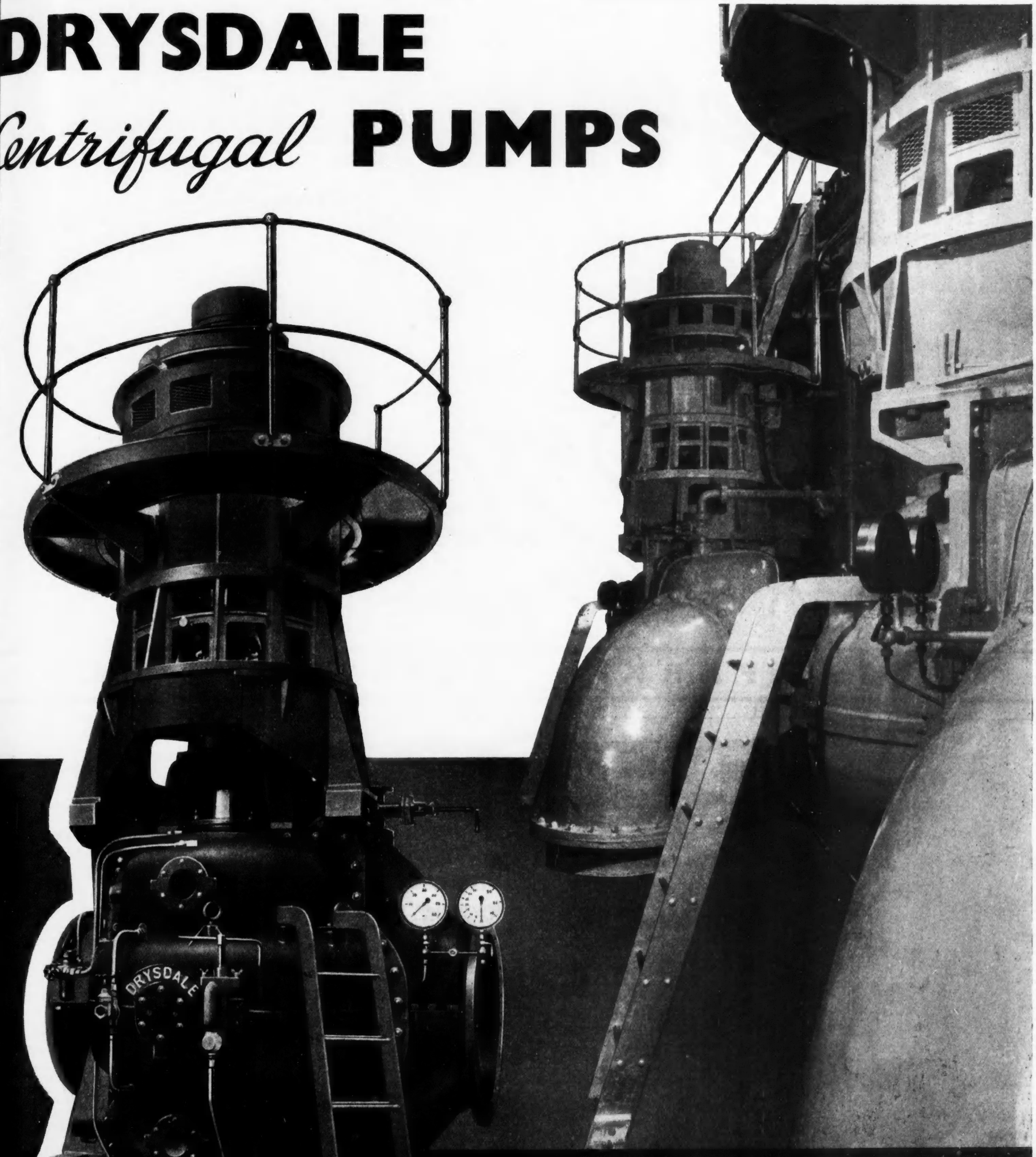

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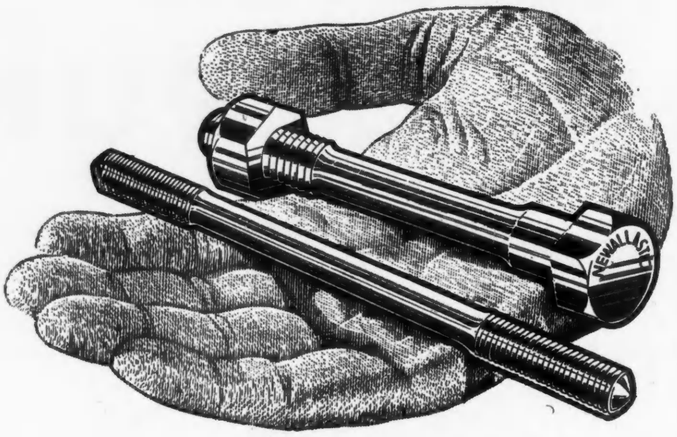

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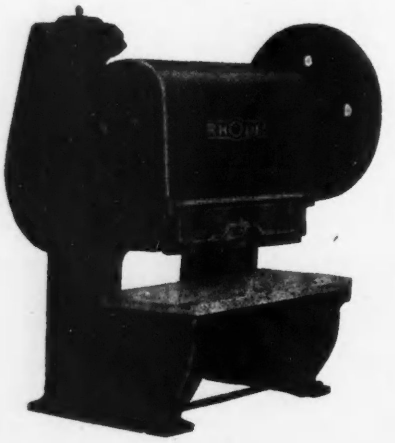

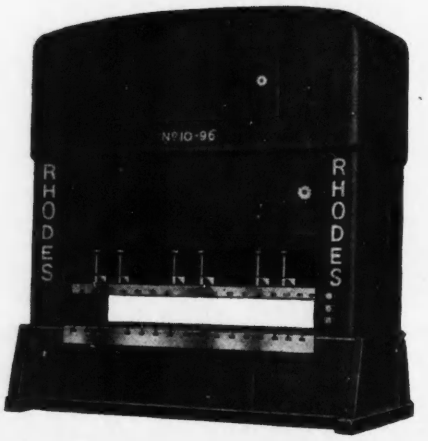

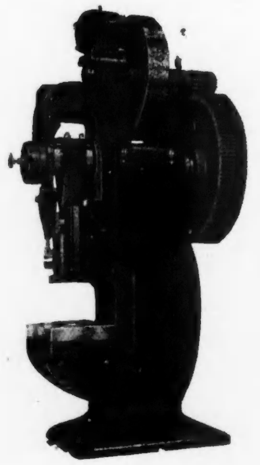

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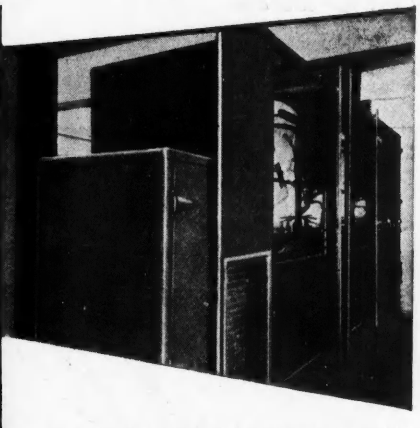

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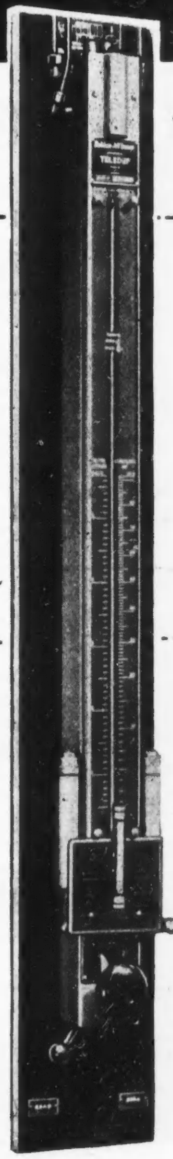

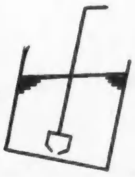

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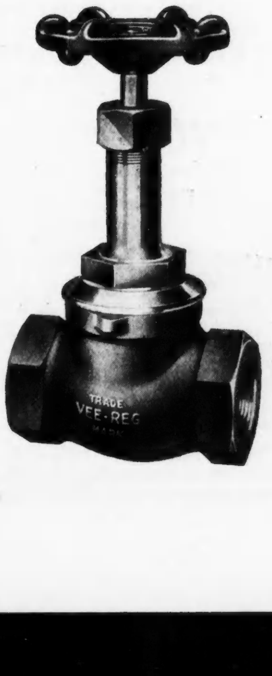

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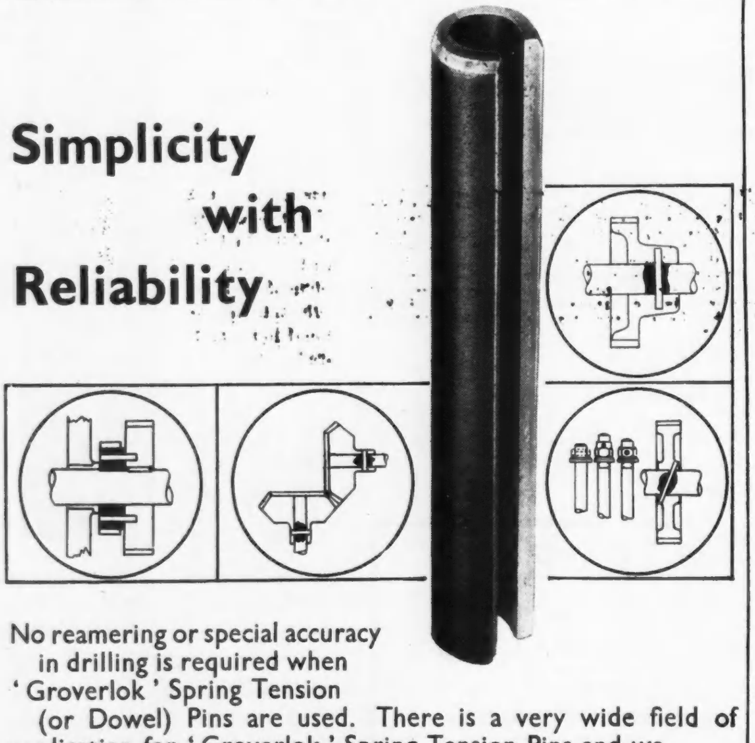

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page 600

STEAM-DRIVEN GENERATOR SETS

3000-kW., 6600/3/50 Pass-Out, Condensing Turbo-Alternator Set by MET.-VICK, designed for 340 lb. W.P., initially 600 deg. F. temp., also suitable for the following duties :—

Output, kW.	Pass-Out, lb. hr.	Pressure
3000	60,000	40
1800	40,000	110
1800	40,000	110 and 40

Double Pass-Out at 1000-kW. fully condensing, speed 1000 r.p.m. through reduction gear.

2500-kW. (3125-kVA.) Turbo-Alternator Set by B.T.H. for 440/3/50, 4 wire, pressure 255 lb. sq. in., turbine designed to operate as a pass-out set with quantities up to 55,000 lb. hr. at pressures 18/35 p.s.i.g., with surface condenser, circulating pumps, &c., speed 3000 r.p.m.

2000-kW. (2350-kVA.) Condensing Turbo-Alternator Set by BELLISS & MORCOM/L.D.M., for 6600/3/50, steam pressure 180/250 lb. sq. in., overload 25 per cent for two hours, surface condenser mounted below turbine. ■

(1800/2000-kW.) Condensing or Pass-Out Turbo-Alternator Set by MET.-VICK, steam pressure 250 lb. sq. in., 650 deg. F., speed 1000 r.p.m. through reduction gear, alternator 400/3/50.

1500-kW. Turbo-Alternator Set by D. ADAMSON/BROWN BOVERI, steam pressure 230/250 lb. sq. in., 65/50 lb. back pressure, alternator 400/3/50, 4 wire. This set can be adjusted for steam pressures 150/160 lb. sq. in., 15 lb. back pressure.

1000-kW. Condensing, Geared Turbo-Alternator Set by ALLEN/E.C.C., for 400/3/50, steam pressure 175 lb. sq. in., 600 deg. F., exhausting to 29in. vacuum, speed 1000 r.p.m. through reduction gear.

700-kW. Pass-Out Condensing Turbo-Alternator Set by BELLISS & MORCOM/BRUCE PEEBLES, for 400/440/3/50, max. cont. rating 700-kW. with steam at 190 lb. sq. in., superheat 100 deg. F., exhausting to 28½in vacuum, passing out 8000 lb. steam hr. at 10 lb. pressure, also bleed available for 2000 lb. hr. at 50 lb. sq. in., will develop 560-kW. solely condensing, driving through reduction gear 4500 down to 1000 r.p.m., Bruce Peebles alternator, turbine complete with condenser, cooling surface 910ft., with direct-driven extraction pump.

500-kVA. Steam-driven Generating Set by BELLISS & MORCOM/E.E.C., for 400/440/3/50, steam pressure 140/150 lb. sq. in., 450 deg. F. total temp., 25/26in. vacuum exhaust, but has been adjusted for 150 lb. sq. in., with 10 per cent overload, back pressure 15 lb.

00-kW. Turbo-Alternator Set by W. H. ALLEN/MATHER & PLATT, for 400/440/3/50, steam pressure 240 lb. sq. in., 100 lb. back pressure, suitable for operation with steam down to 160 lb. against 30 lb. back pressure.

500-kW. (625-kVA.) Steam Turbo-Alternator Set by B.T.H., impulse back-pressure turbine, steam pressure 300 lb. sq. in., 150 deg. superheat exhausting against back pressure 60 lb. sq. in., steam consumption 52·6 lb. kWh., speed 3000 r.p.m., steam regulating relay valves at steam chest operated through oil turbo-motor, oil control through enclosed governor, direct coupled to 500-kW. alternator, 440/3/50, 821 amps., 0·8 p.f., overhung exciter rotor, exciter 5-kW., 150 amps., max. 90V., min. 20V., with switchboard overall dimensions 15ft. × 7ft. × 8ft. 6in. high.

500-kW. (625-kVA.) Pass-Out, Condensing Steam Turbo-Alternator Set by BELLISS & MORCOM/E.E.C., for 400/3/50, turbine designed for 750 h.p. at 600 r.p.m., with steam at 190 lb. hr. at 60 lb. g., balance exhausting to condenser, vacuum 28½in.

400-kW. (500-kVA.) Steam-driven Alternator Set by BELLISS/E.E.C., for 400/3/50, steam pressure 130/165 lb. sq. in., 10/20 lb. back pressure, speed 375 r.p.m.

400-kW. Steam-driven Alternator Set by BELLISS & MORCOM/E.E.C., steam pressure 115 lb. sq. in. initially, superheat 447 deg. F. at stop valve, speed 375 r.p.m., suitable for pressures up to 150 lb. sq. in. and back pressures up to 15 lb. sq. in., alternator 400/3/50.

428-kVA. Steam-driven Alternator Set by BELLISS & MORCOM/SIEMENS, for 550/3/50, steam pressure 160/180 lb. sq. in., against 15 lb. back pressure, speed 375 r.p.m.

350-kW. W. H. ALLEN/L.D.M. Geared Turbo-Alternator Set, 180 lb. pressure, 575 deg. F., pass-out 13,000 lb. per hour at 25 lb. pressure, remainder exhausting to condenser, alternator 400/440/3/50, 4 wire.

300-kW. (400-kVA.) Turbo-Alternator Set by ALLEN/HARLAND, steam pressure 275 lb. against 48 lb. back pressure, superheated 535 deg. F., 25 per cent. overload for 2 hrs, could be arranged for operation at 160 lb. sq. in., 10 lb. back pressure, speed 8000/1000 r.p.m. through reduction gear, alternator 400/3/50.

230-kW. (287·5-kVA.) Steam-driven Alternator Set by BROWETT LINDLEY/MATHER & PLATT, for 440/3/50, steam pressure 180 lb. sq. in., speed 375 r.p.m.

250-kW. Steam-driven Generating Set by BELLISS/L.D.C., for 220V. D.C., steam pressure 115/135 lb. sq. in., 15 lb. back pressure, speed 425 r.p.m.

200-kW. (250-kVA.) Steam-driven Alternator Set by BELLISS & MORCOM/MATHER & PLATT, for 400/3/50, engine vert., compound "V" type, designed for 293 h.p., with steam at 150 lb. sq. in. superheated, 420 deg. F. total temp., suitable for back pressures 5–25 lb. sq. in., speed 428 r.p.m.

DIESEL-DRIVEN GENERATING SETS

480-kW. (600-kVA.) Diesel-driven Alternator Set by BRITISH POLAR ENGINES/ASEA, engine vert., 5 cyl., 2 stroke, water cooled, type K35M, speed 250 r.p.m., cam-controlled air starting acting on two cylinders, reciprocating type scavenge air pump direct driven from crankshaft, direct-mounted reciprocating type cooling water circulating pump, engine direct driving through solid coupling 600-kVA. alternator, 440/3/50, 0·8 p.f., 787 amps., 250 r.p.m., excitation 110V., 124 amps., with starting compressor set ; would consider rewinding for 600-kVA., 440 or 520V/3/60, 4 wire with engine at 300 r.p.m. or, alternatively, 220/3/50, 4 wire, with engine at 300 r.p.m.

397-kW. Set by MIRRLEES/BRUSH, engine type JS6, vert., 6 cyl., 4 stroke, water cooled, speed 750 r.p.m., direct-coupled alternator, 400/3/50, 0·8 p.f., with overhung exciter.

330-kVA. Diesel-driven Alternator Set by PAXMAN/B.T.H., engine type 12RPH, 4 stroke, radiator fan cooled, developing 400 h.p. at 1000 r.p.m., Bosch fuel pump with lubricating and fuel oil filters, Serck radiator, direct-coupled alternator 420/3/50, 4 wire, 0·8 p.f., revolving field type with direct-coupled exciter, complete with switchgear.

330-kVA. Diesel Alternator Set by DAVEY PAXMAN/B.T.H., engine 400 h.p., type 12RPH, vert., 12 cyl., 4 stroke, water cooled, direct-coupled alternator 380/440/3/50, 1000 r.p.m.

260-kVA. (208-kW.) Diesel Alternator Set by MIRRLEES/B.T.H., engine 300 b.h.p., vert., 7 cyl., 4 stroke, 600 r.p.m., direct-coupled alternator 400/3/50, 0·8 p.f., with direct-coupled exciter.

Two Diesel-driven Alternator Sets by CROSSLEY/B.T.H., engine 330 b.h.p., type XVD6, 6 cyl., 4 stroke, 600 r.p.m., direct-coupled alternator 420/3/50, 4 wire.

169-kVA. (135-kW.) BELLISS & MORCOM/L.D.C., engine vert., 3 cyl., 4 stroke, speed 375 r.p.m., direct-coupled alternator 400/3/50.

152·5-kVA. (122-kW.) Diesel-driven Alternator Set by MIRRLEES/MET.-VICK, engine type ULA5, 12-hr. rating 174 h.p., cont. rating 157 h.p., speed 500 r.p.m., direct-coupled alternator 400/3/50, 4 wire, 0·8 p.f.

135-kW. (169-kVA.) Diesel-driven Alternator Set by CROSSLEY/G.E.C., engine type QVD4, 184 h.p., vert., 4 cyl., 4 stroke, 12-hr. rating 500 r.p.m., direct-coupled alternator 415/3/50, 4 wire, 0·8 p.f.

130-kW. (162·5-kVA.) Alternator Set by PAXMAN/BRUSH, engine 200 h.p., type R.P.H., 6 cyl., encl., 4 stroke, water cooled, speed 1000 r.p.m., direct-coupled alternator 410/3/50, 4 wire, 0·8 p.f.

125-kVA. (100-kW.) Diesel Alternator Set by BLACKSTONE / CROMPTON PARKINSON, engine type E.P.V., 170 b.h.p., 500 r.p.m., direct-coupled revolving field alternator 400/440/3/50, with direct-coupled exciter.

125-kVA. (100-kW.) Alternator Set by CROSSLEY/CROMPTON PARKINSON, engine 165 h.p., type D.R.S.6, vert., 6 cyl., 2 stroke, speed 500 r.p.m., direct-coupled alternator 3150/3/50, or will be converted to 400/3/50 if desired.

118-kW. MIRRLEES, BICKERTON/L.D.C., engine type ULA5, vert., 5 cyl., 4 stroke, 12-hr. rating 168 h.p., 24-hr. rating 155 h.p., 107-kW., 1-hr. rating 185 h.p., 130-kW., direct-coupled alternator 415/3/50, 4 wire, 0·8 p.f., speed 500 r.p.m.

98-kVA. Diesel-driven Alternator Set by DAVEY PAXMAN/BRUSH, engine 112 h.p., vert., 6 cyl., 4 stroke, speed 1000 r.p.m., direct-coupled alternator 400/3/50, 4 wire, 0·8 p.f.

93·75-kVA. (75-kW.) Alternator Set by BLACKSTONE/MET.-VICK, engine 110 h.p., type EPV.3, vert., encl., 4 stroke, speed 600 r.p.m., direct-coupled alternator 415/3/50.

78-kVA. GENERAL MOTORS/GENERAL ELECTRIC U.S.A., engine vert., 6 cyl., 2 stroke, radiator fan cooled, 123 h.p., at 1500 r.p.m., alternator 400/3/50, 4 wire, 0·8 p.f.

AIR COMPRESSORS

2450 c.f.m. BELLISS & MORCOM/BRIT. WESTINGHOUSE, vert., 2 stage, 2 crank, double acting, water cooled, suitable for 100 lb. sq. in. pressure, but with existing motor will deliver 2450 c.f.m. at 70 lb. W.P., 245 r.p.m., direct-coupled 450 b.h.p. slipring induction motor, 550/3/50, bell shields, overhung enclosed sliprings, separate floor-mounted vert. intercooler, overall dimensions 17ft. 3in. × 10ft. wide × 11ft. high at compressor from floor level.

1640 c.f.m. BELLISS & MORCOM, vert., 2 crank, 2 stage, double acting, water cooled, W.P. 75 lb. sq. in. at 333 r.p.m., intercooler between stager and aftercooler, direct-coupled 295 h.p. auto. synch. motor by Crompton Parkinson, 400/3/50, 0·8 p.f., with control equipment.

New 600 c.f.m. BROOM & WADE, type E.H., vert., 2cyl., single stage, single acting, water cooled, 310 r.p.m., W.P. 100 lb. sq. in., driven by 135 h.p. slipring Brook motor, 400/3/50.

540 c.f.m. BELLISS & MORCOM, Vert., 2 crank, 4 stage, water cooled, W.P. 440 lb. sq. in., driven by 190 h.p. slipring induction motor by Mather & Platt, speed 300/293 r.p.m.

Two 461 c.f.m. INGERSOLL RAND, type ES–X, horiz., encl., single cyl., single stage, double acting, water cooled, W.P. 100 lb. sq. in., at 325 r.p.m.

320 c.f.m. BROOM & WADE, vert., 2 cyl., 2 crank, 2 stage, water cooled, working pressure 100 lb. sq. in., 460 r.p.m., fitted directly mounted intercooler and floor-mounted aftercooler, vee belt driven by 67½ h.p. slipring Mather & Platt motor, 400/3/50.

310 c.f.m. WORTHINGTON SIMPSON, type DA36, vert., 2 cyl., 2 stage, water cooled, W.P. 100 lb. sq. in., 930 r.p.m., driven by 80 h.p. S/R motor by Crompton Parkinson, 400/3/50, with control gear ; alternatively can be supplied with a larger motor to give 150 lb. W.P., 298 c.f.m. at 960 r.p.m.

Three 300 c.f.m. TILGHMAN, type FC.6.BY, vert., 2 stage, single crank, tandem type, speed 360 r.p.m., W.P. 100 lb. sq. in. with intercooler and aftercooler, vee belt driven by 67½ h.p. slipring motor by E.E.C., 400/3/50.

246 c.f.m. INGERSOLL RAND, Model 50, 4 L.P. and 2 H.P. cylinders, fitted air governor and unloader and radiator type intercooler and aftercooler, W.P. 100 lb. sq. in., vee belt driven by 60 h.p. slipring L.D.C. motor, 400/3/50, speed 1450 r.p.m.

194/114 c.f.m. WORTHINGTON, U.S.A., 2 stage, air cooled, with radiator fan cooled intercooler, vee belt driven by 40 h.p. S/C motor by G.E. of America.

140 c.f.m. WORTHINGTON SIMPSON, Model DA.18, vert., single cyl., 2 stage, water cooled, 100 lb. sq. in. W.P. at 950 r.p.m., built-in intercooler driven by 32 h.p. S/R motor by Crompton Parkinson, 400/3/50, with control gear.

130 c.f.m. BROOM & WADE, type D.22, vert., 2 cyl., single stage, single acting, water cooled, W.P. 100 lb. sq. in., speed 420 r.p.m., driven by new 30 h.p. Brook slipring motor, 400/3/50.

100 c.f.m. BELLISS & MORCOM, 6 stage, 2 crank, vert., for use with gas or air for up to max. pressure 3600 lb. sq. in., vee belt driven by 58 h.p. slipring motor by L.D.C., 400/3/50, speed 1450 r.p.m.

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6900 g.p.m., 26ft. head, GWYNNE Centrifugal Pump, 18in. suction and delivery, vee belt driven by 80 b.h.p. Ruston horiz. twin-cyl., Diesel engine, speed 300 r.p.m.

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Two 2500 g.p.m., 100ft. hd., Lono. Pumps by MATHER & PLATT, type 9L, C.I. case and bronze impeller, 11in. suction, 9in. delivery, direct-coupled 125 h.p. Mather & Platt motor, 400/3/50.

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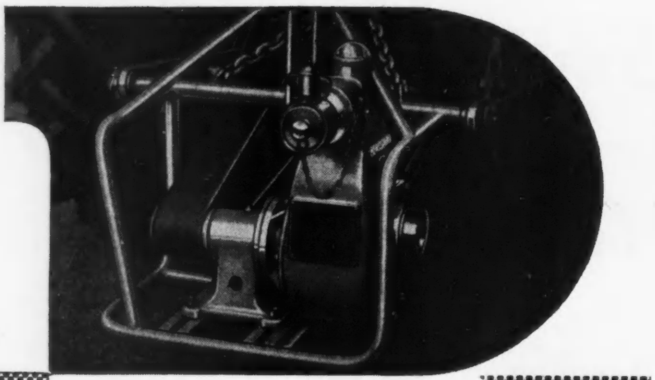

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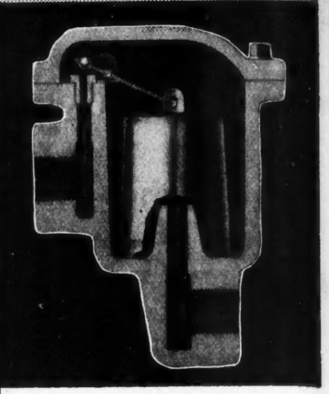

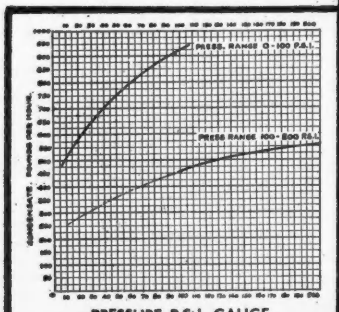
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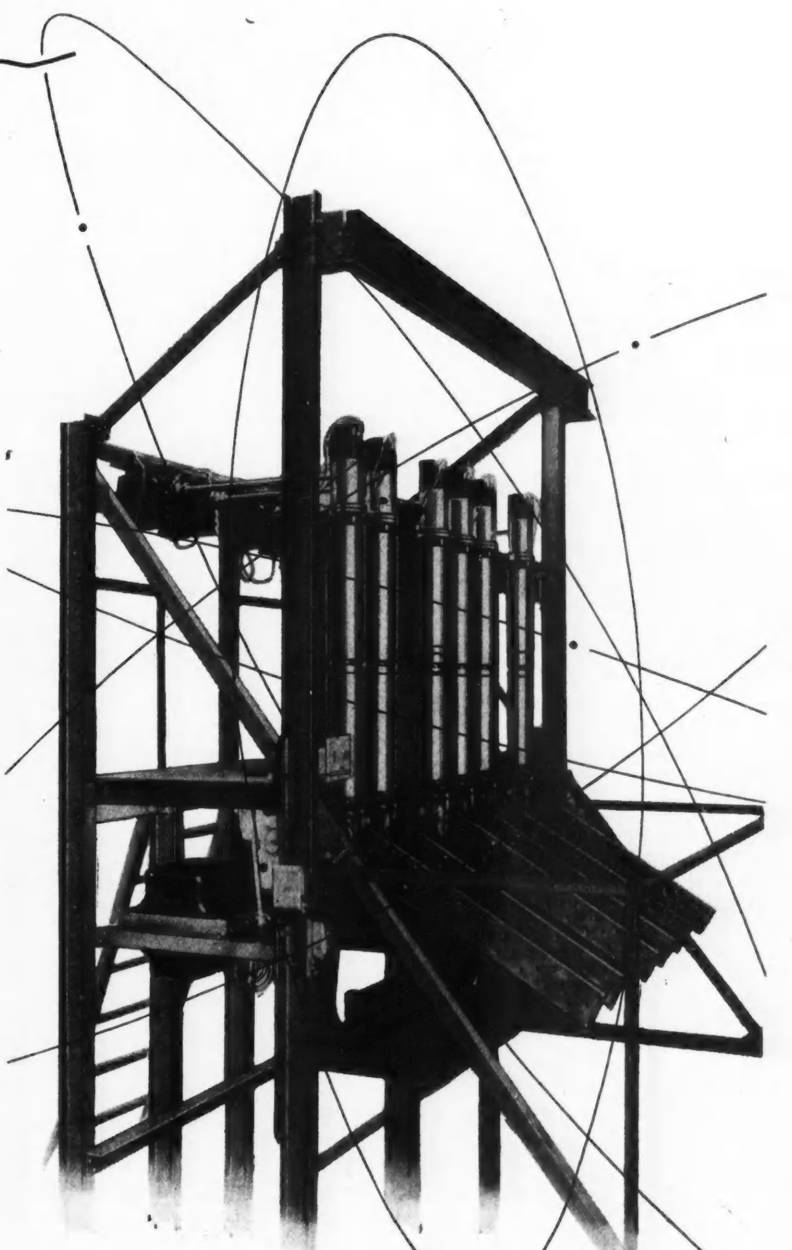

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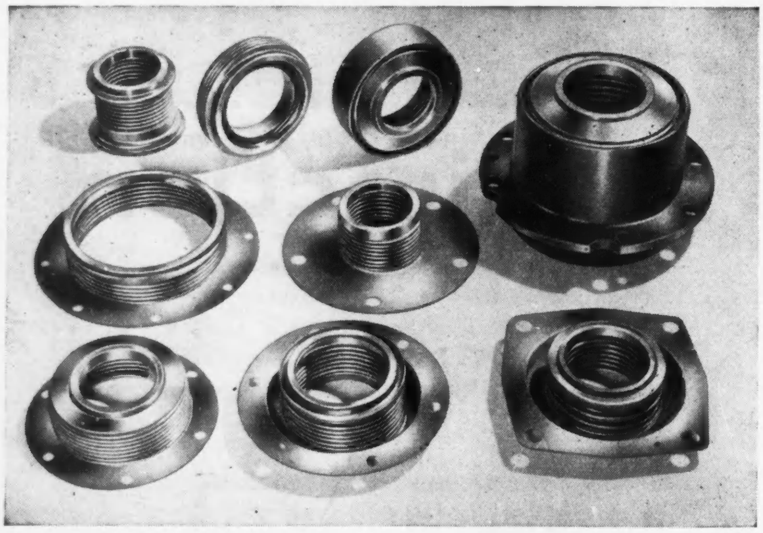

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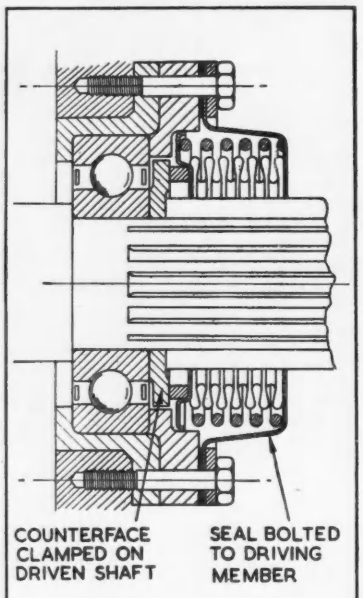
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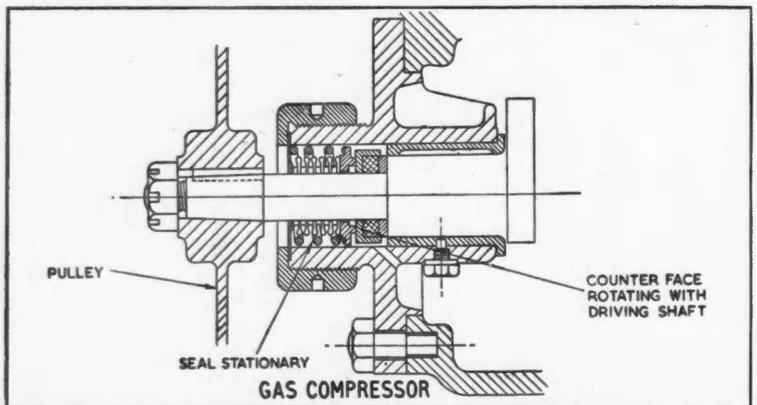

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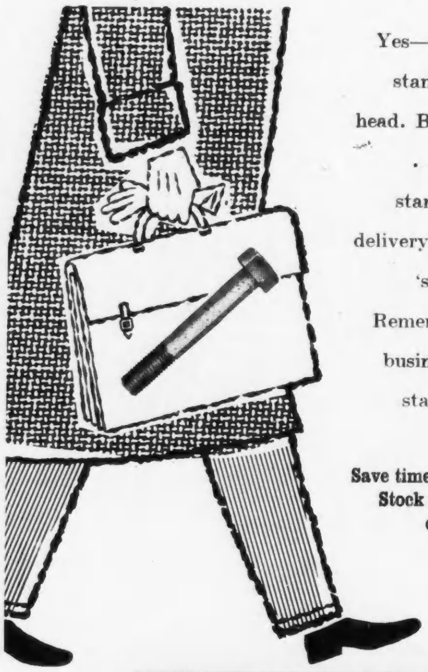

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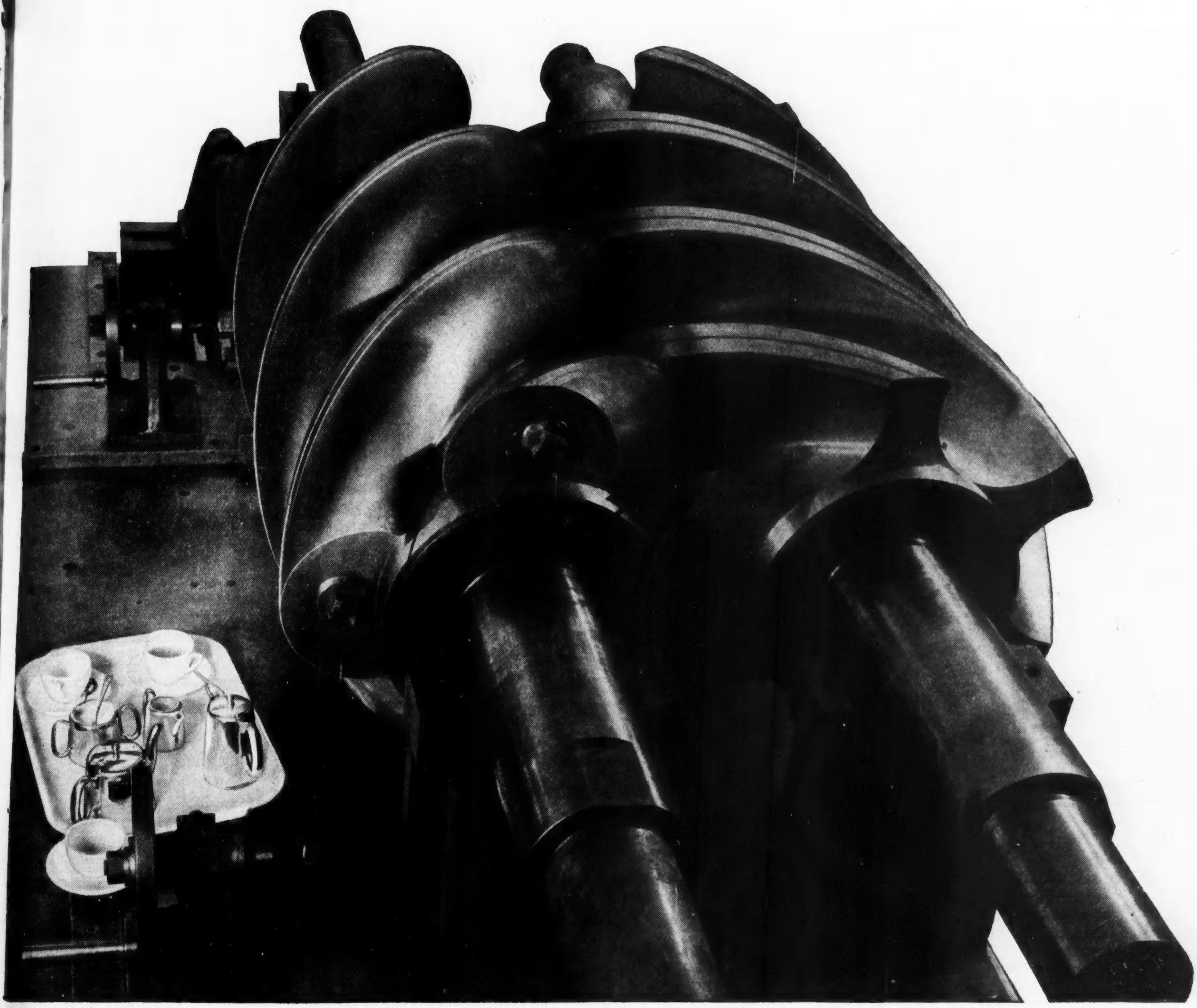

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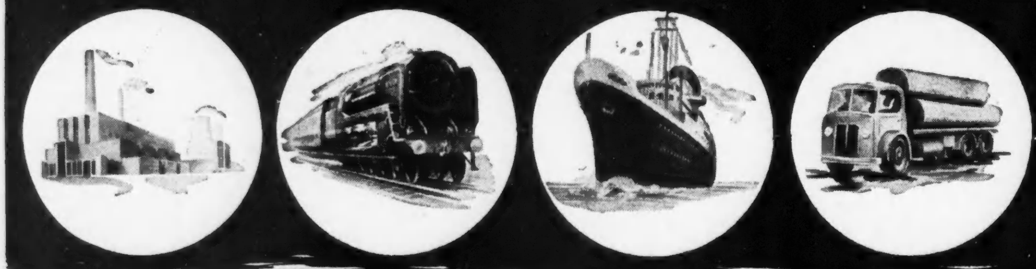

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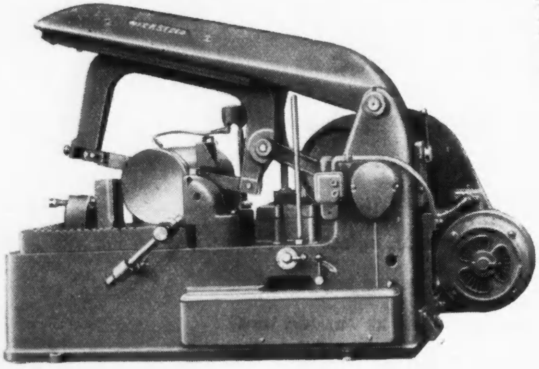

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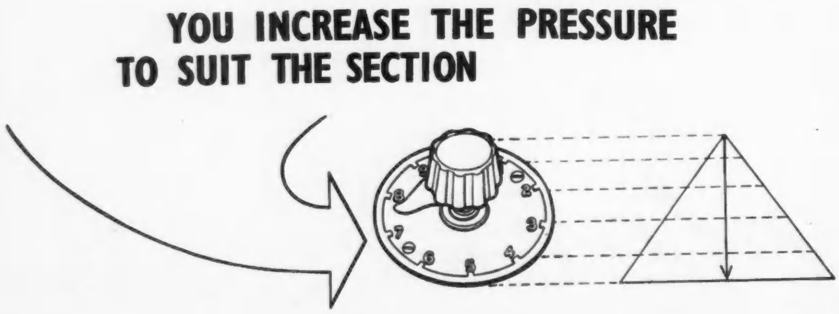

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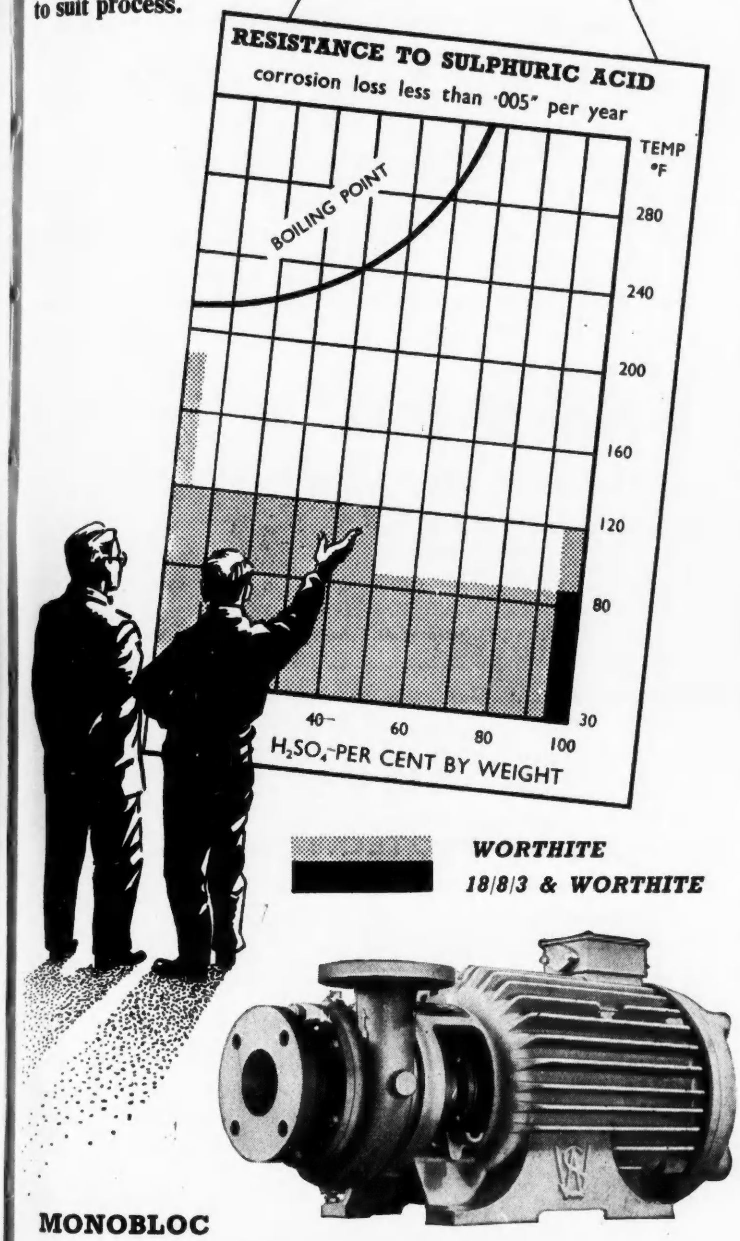
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200
160
120
80
30
BOILING POINT
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60
80
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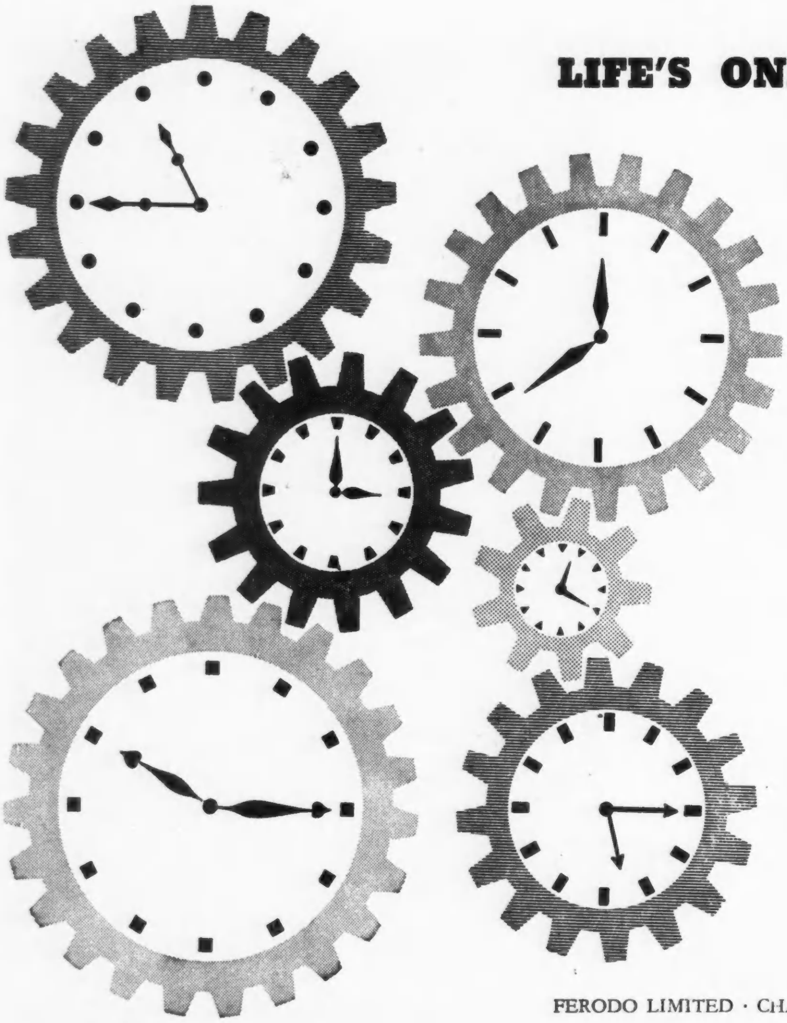

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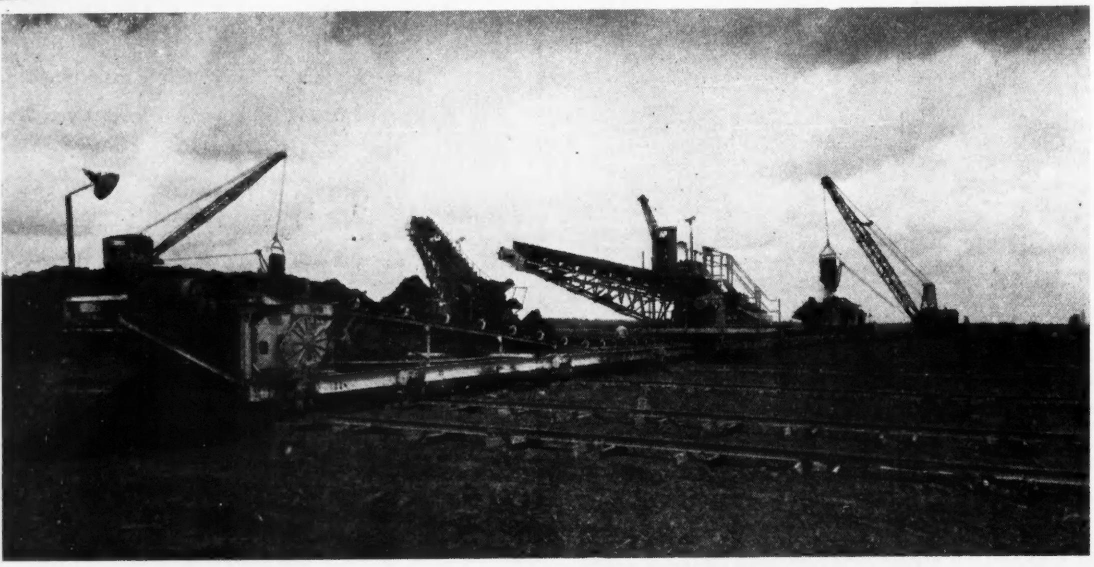

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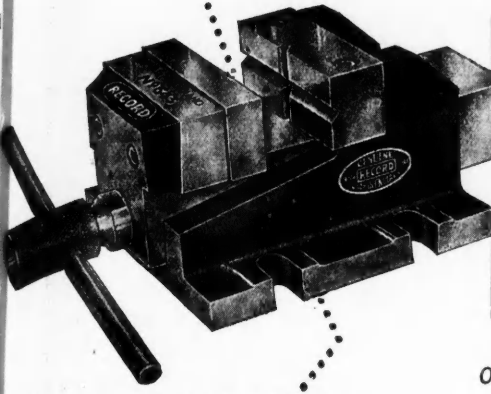

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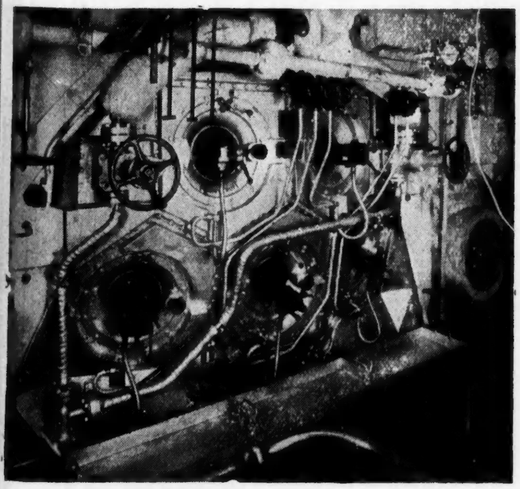

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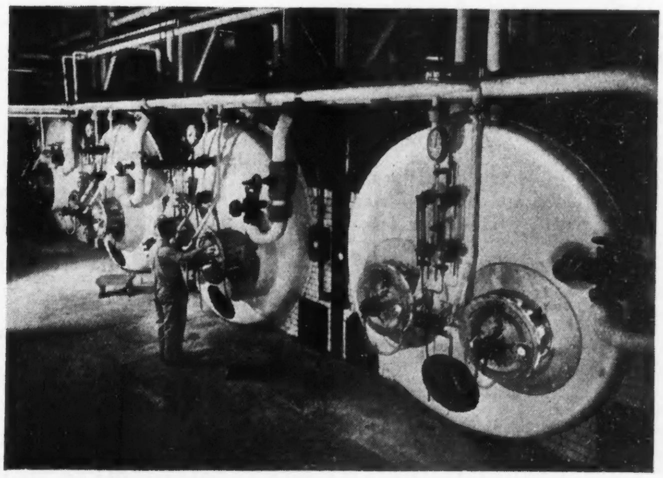

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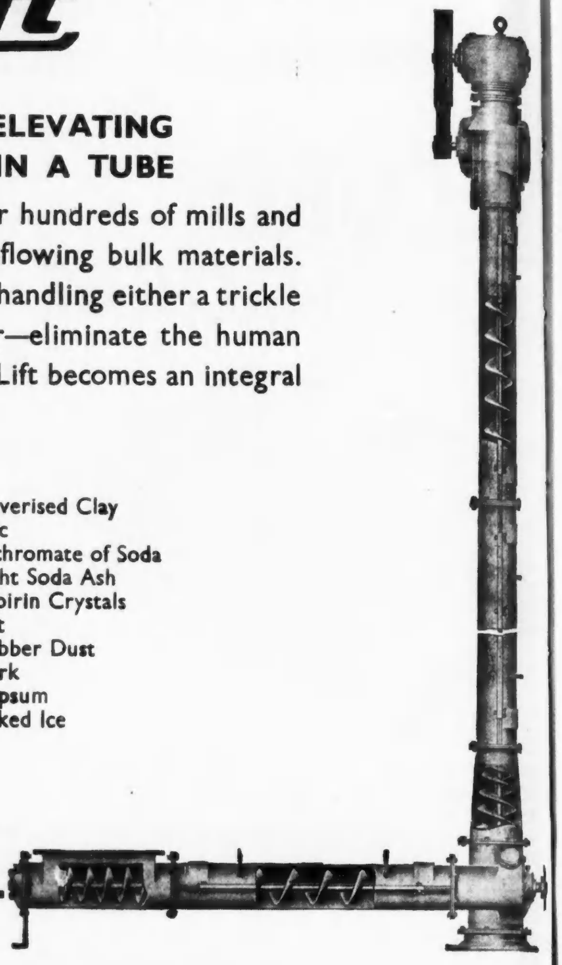

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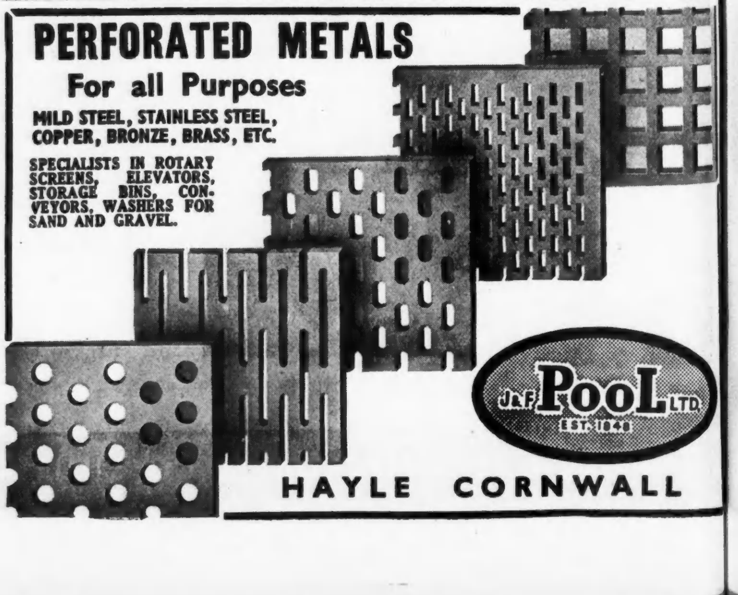

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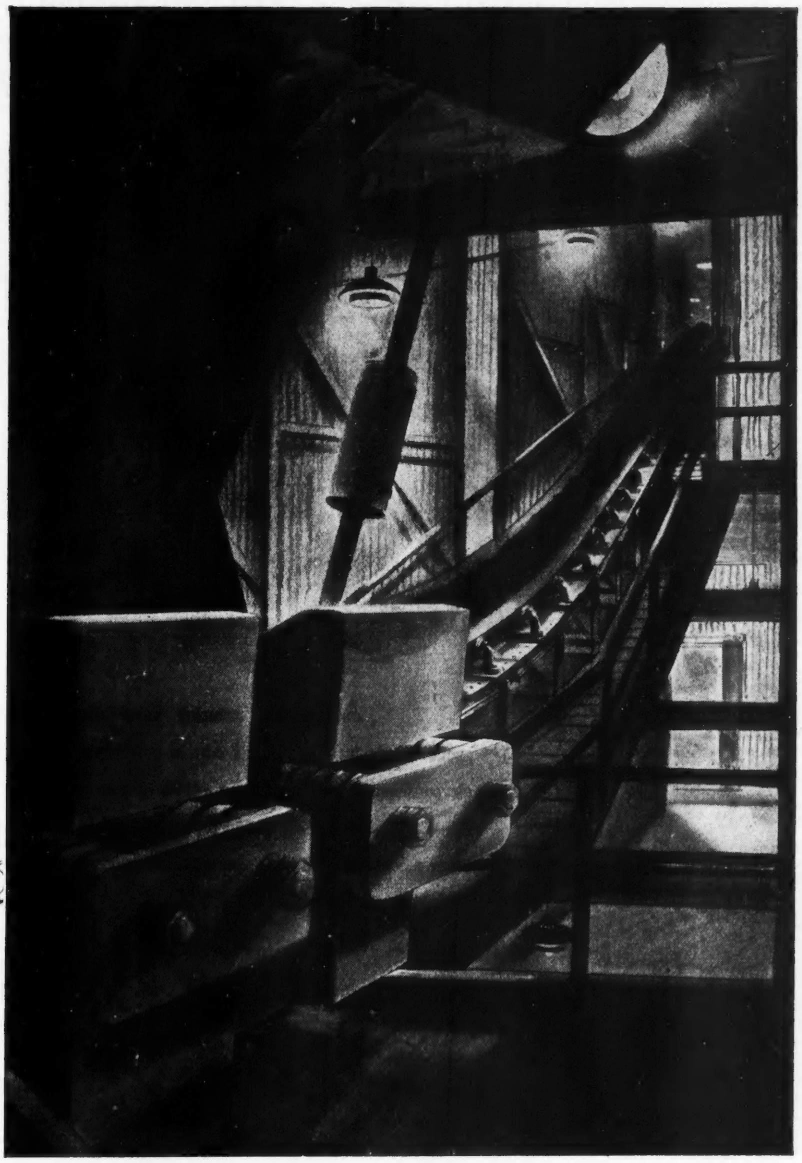

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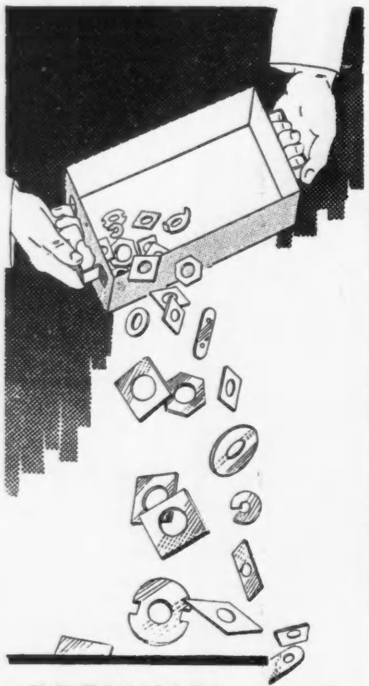

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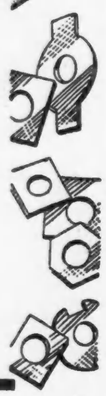

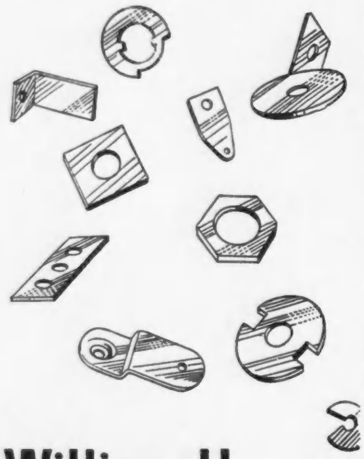

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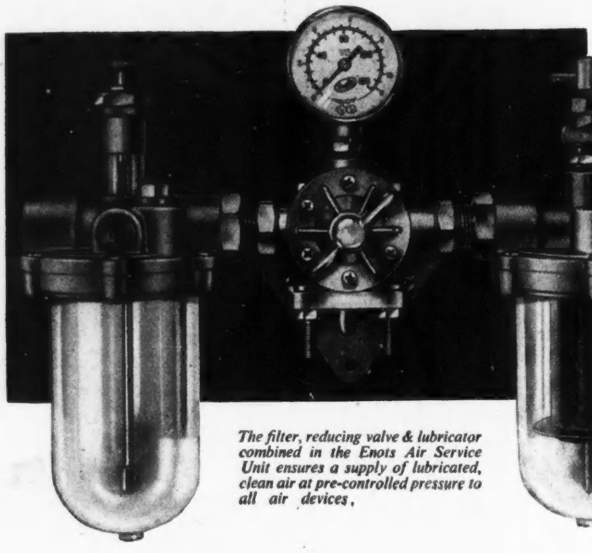
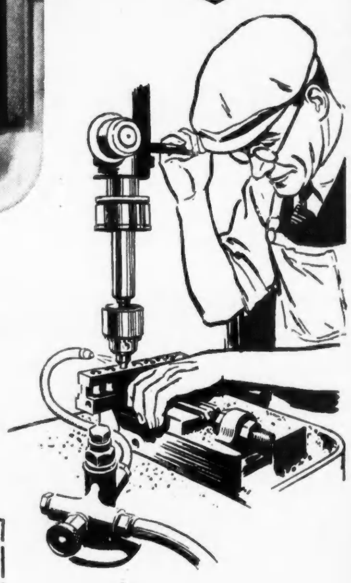


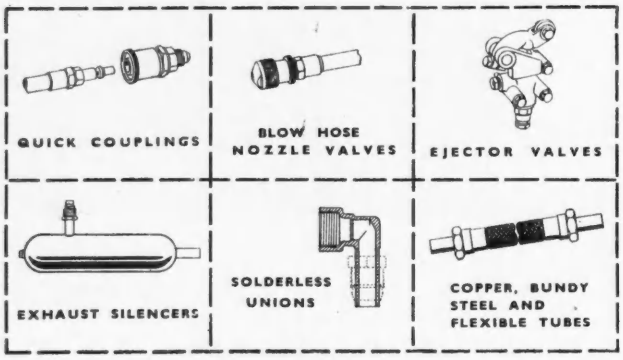
The filter, reducing valve & lubricator combined in the Enots Air Service Unit ensures a supply of lubricated, clean air at pre-controlled pressure to all air devices.

This man is saving money

He is in fact, saving as much as 90% in compressed air consumption by using an ENOTS PUFFER VALVE in place of an open ended pipe for the displacement of swarf. A leak in a 100 lb. per sq. inch air line, equivalent to a $\frac{1}{16}$" diameter hole will pass 390 cu. ft. of free air per hour and waste the equivalent of 2 tons of coal per year (2,500 hours operation).



A pressure reducing valve fitted to almost any pneumatic device will save its cost in a very short time by reducing air consumption. At how many points in your works are you using full line pressures of up to 100 lb. per sq. inch where 80, 60 or even lower pressures would be adequate? Savings are more or less in direct proportion to pressure reduction.



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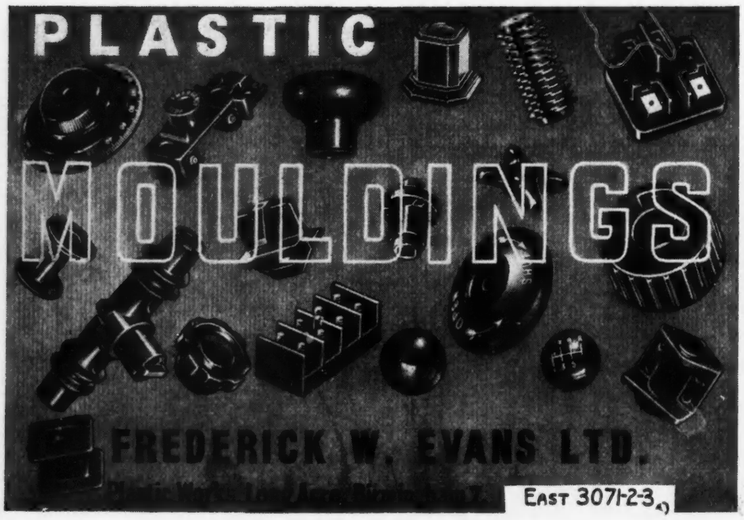

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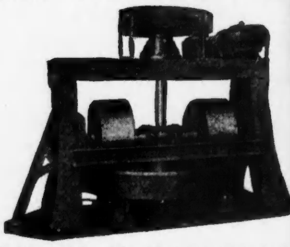

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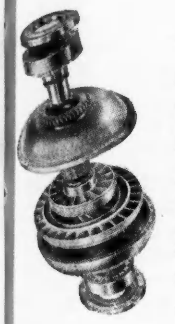

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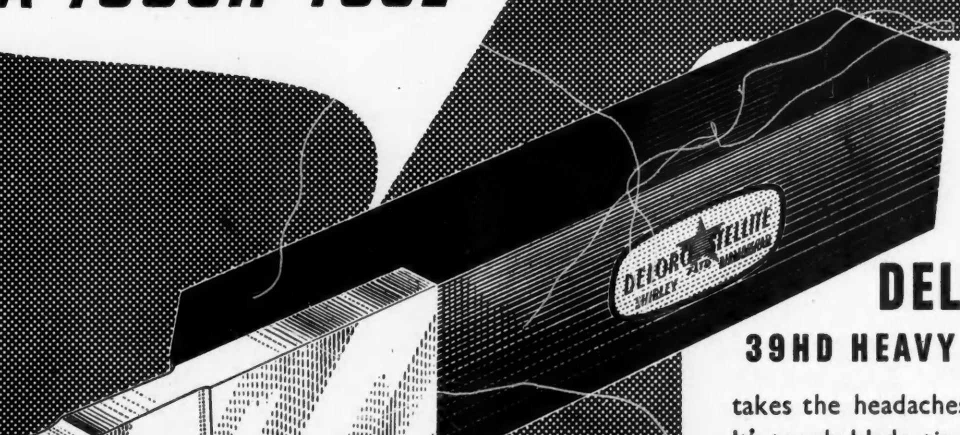

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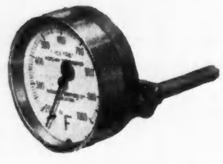

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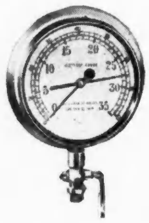

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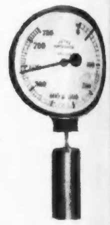

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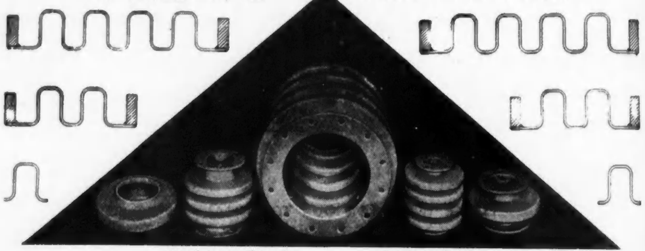

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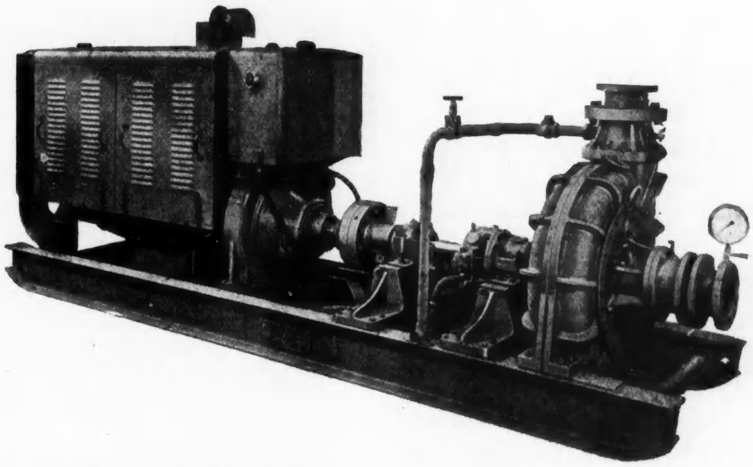

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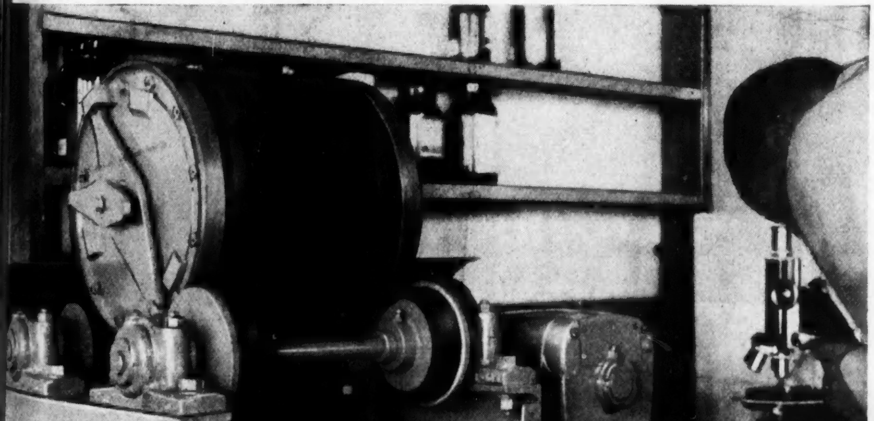

Illustrated: Model C with front roller-guard removed.

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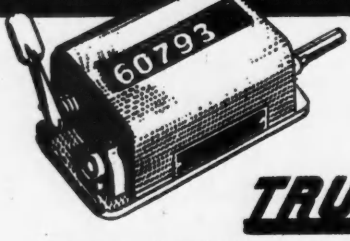

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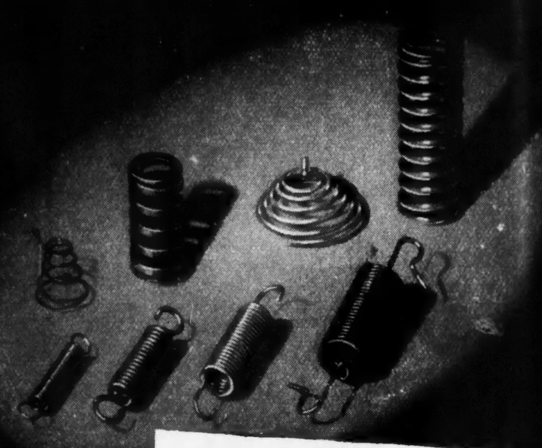

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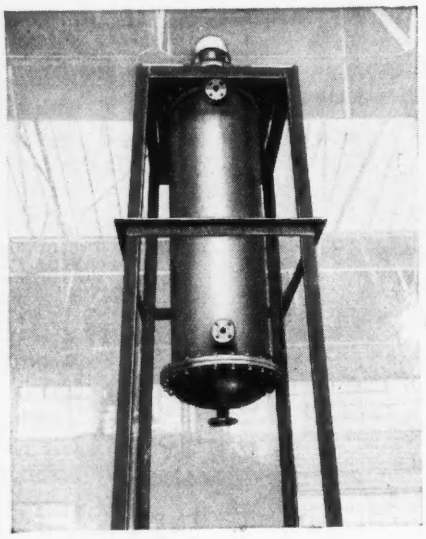

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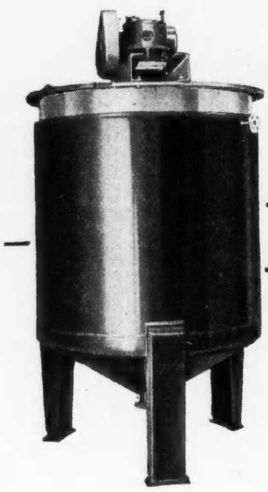

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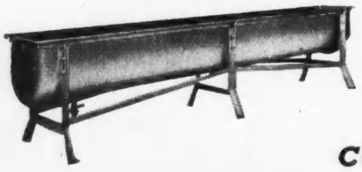

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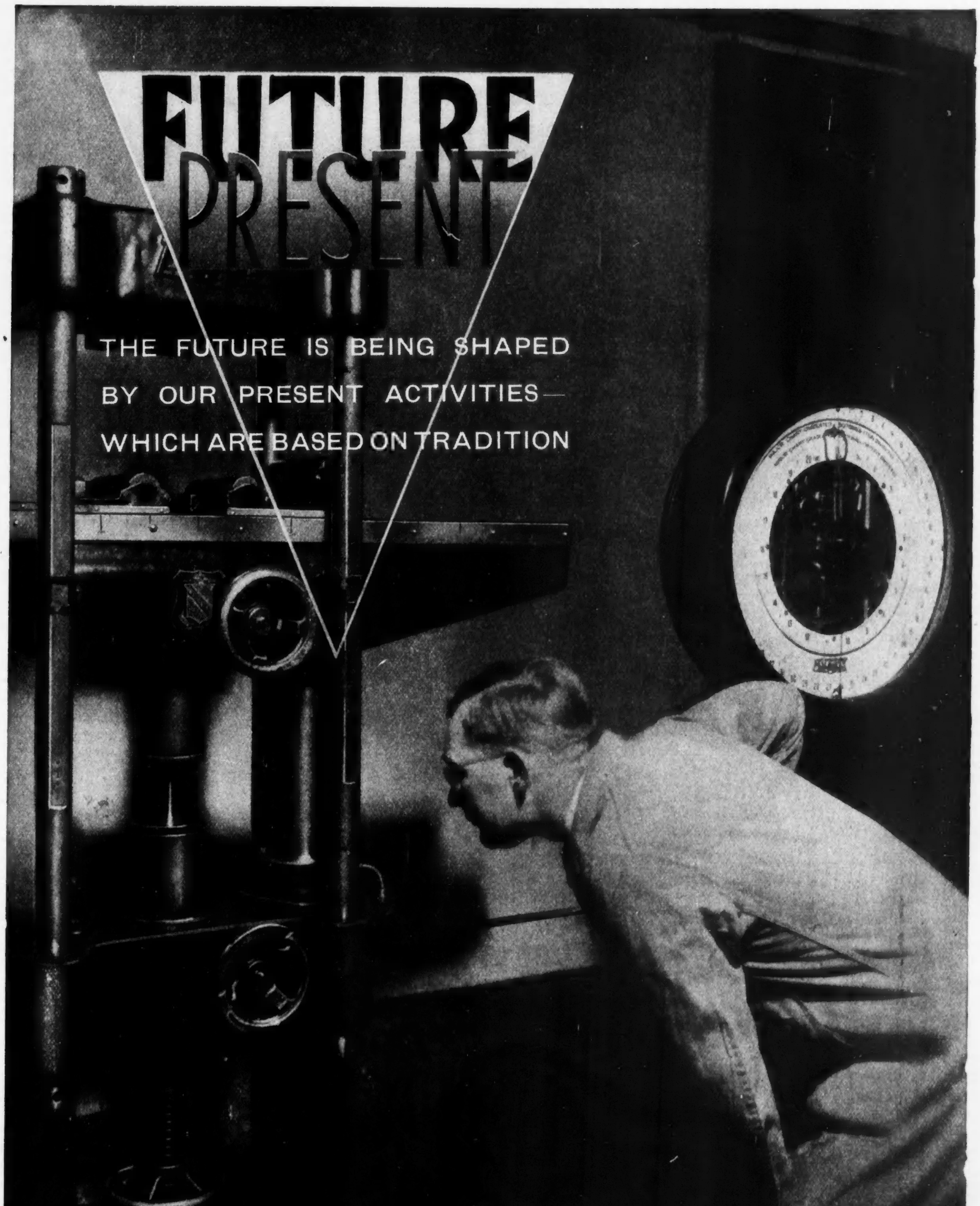
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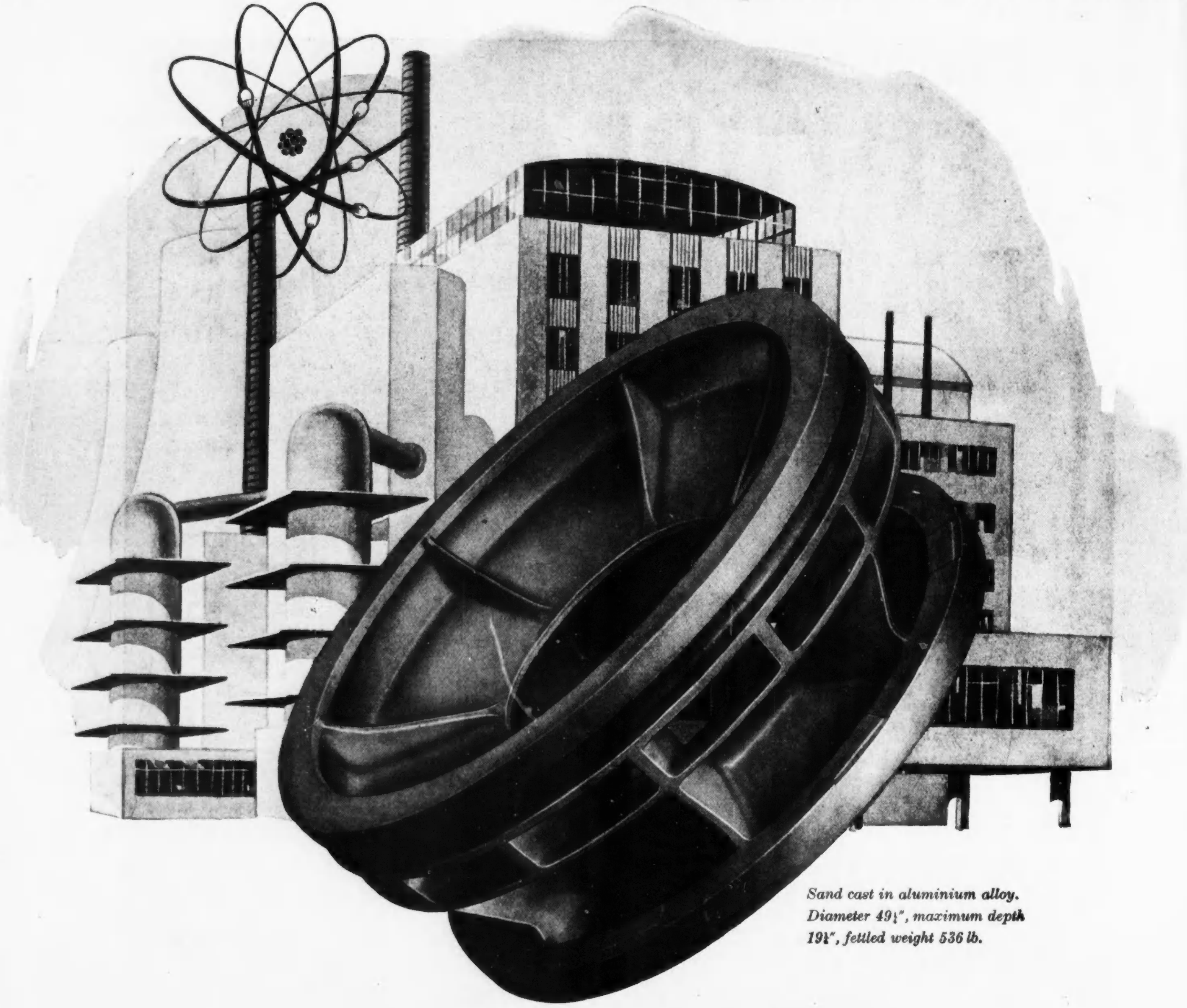

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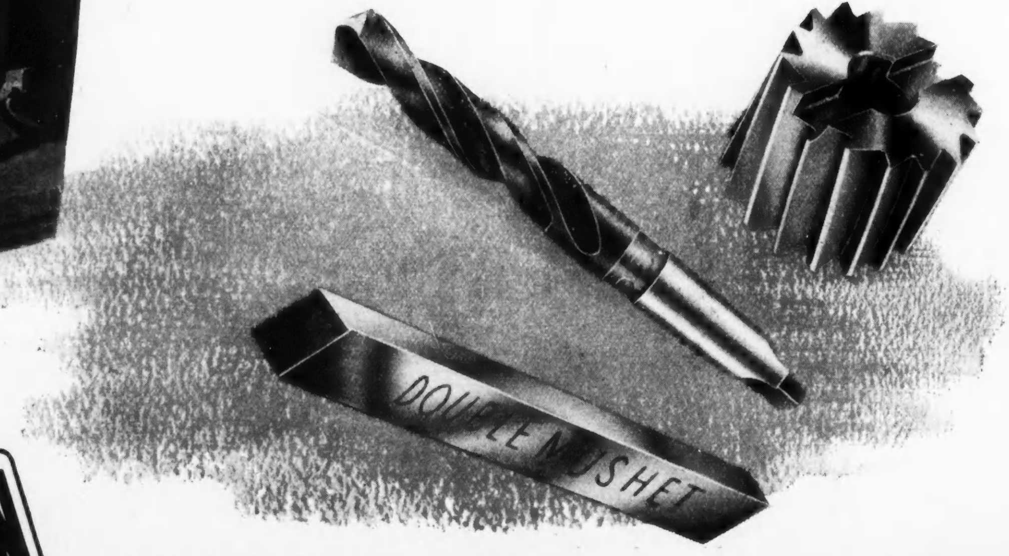

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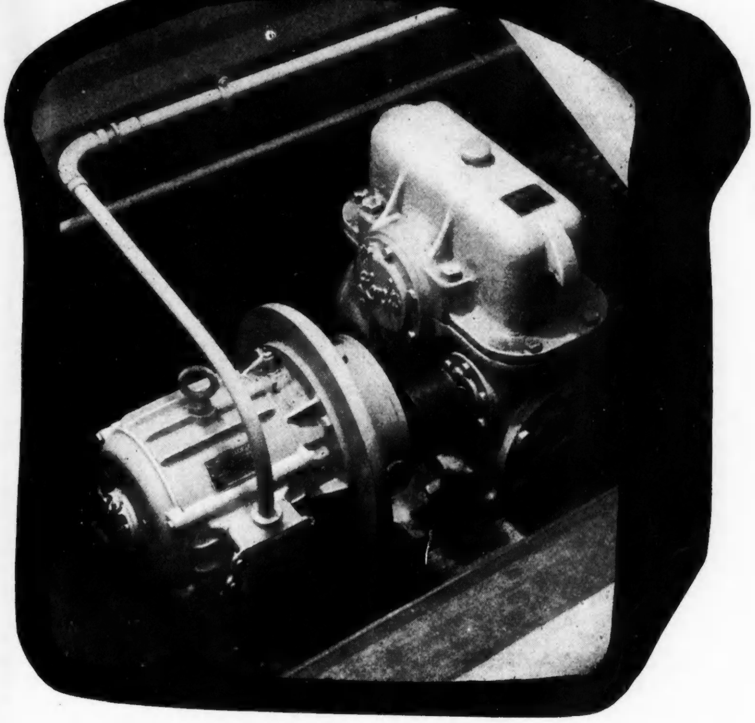

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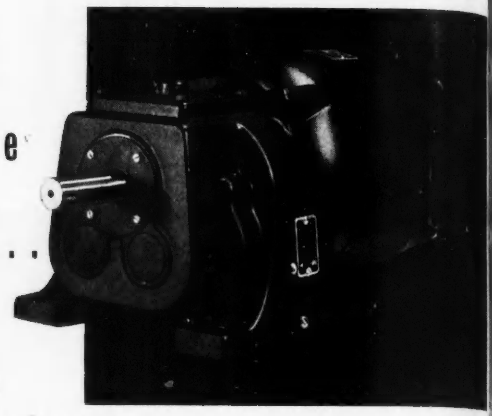

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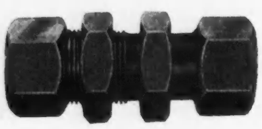

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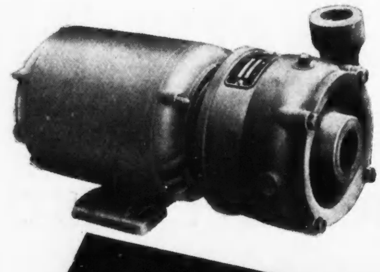

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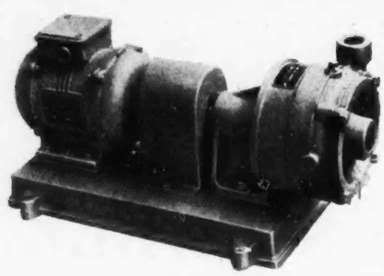

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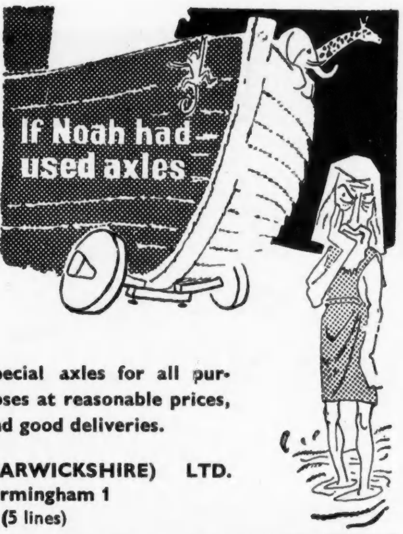
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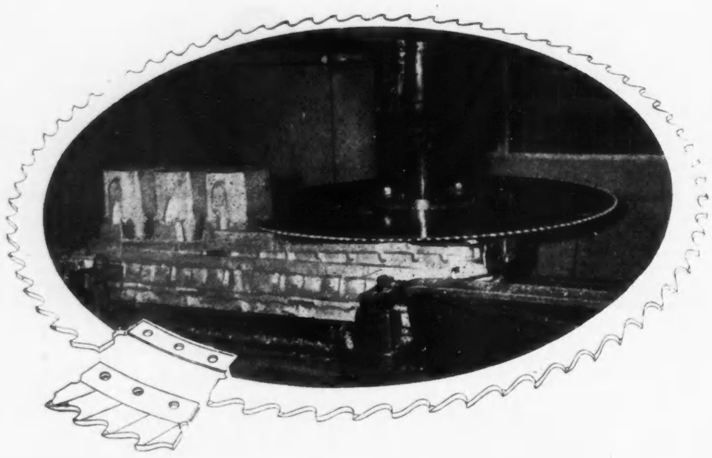

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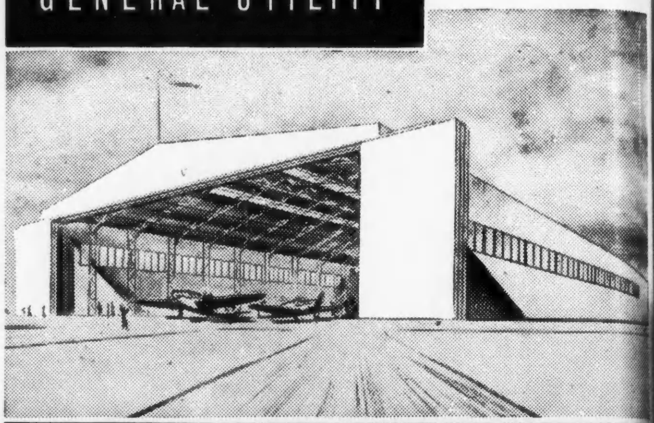

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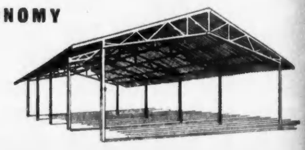

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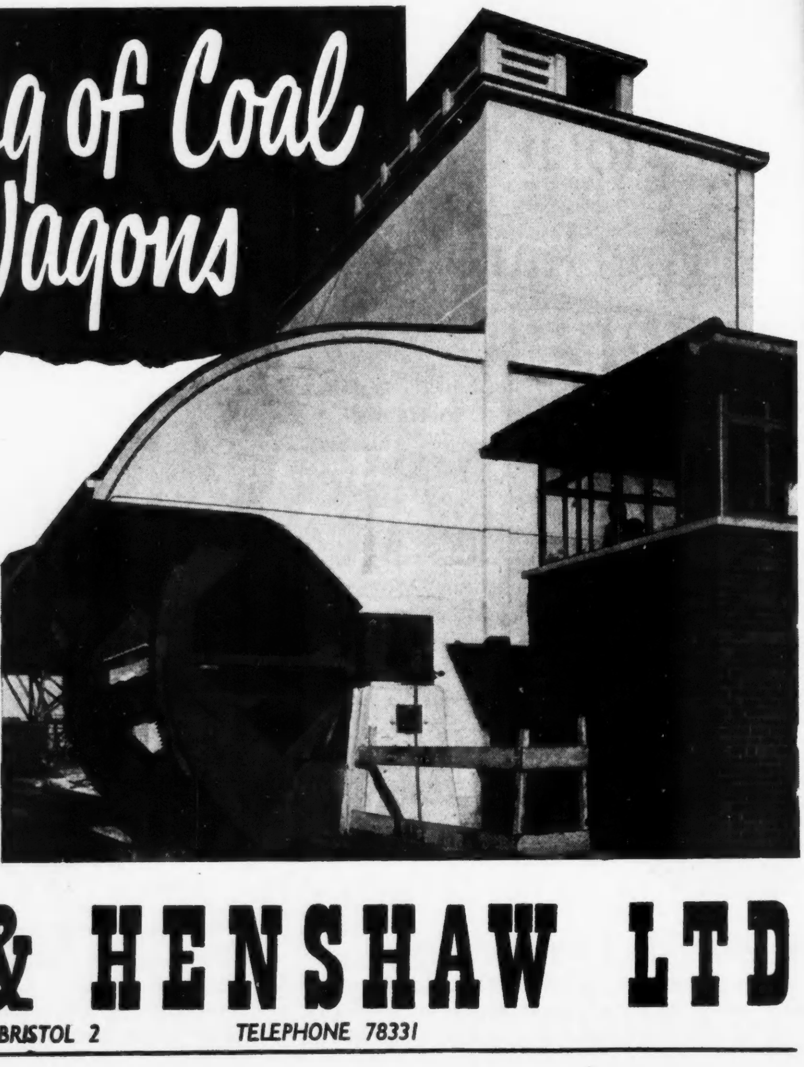

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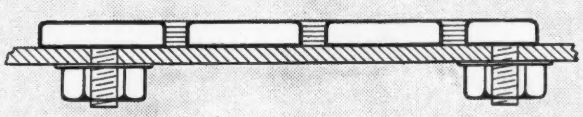

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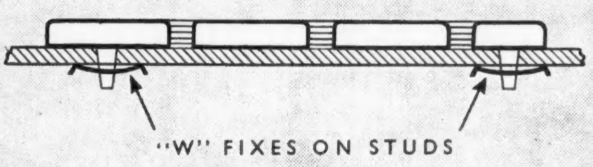

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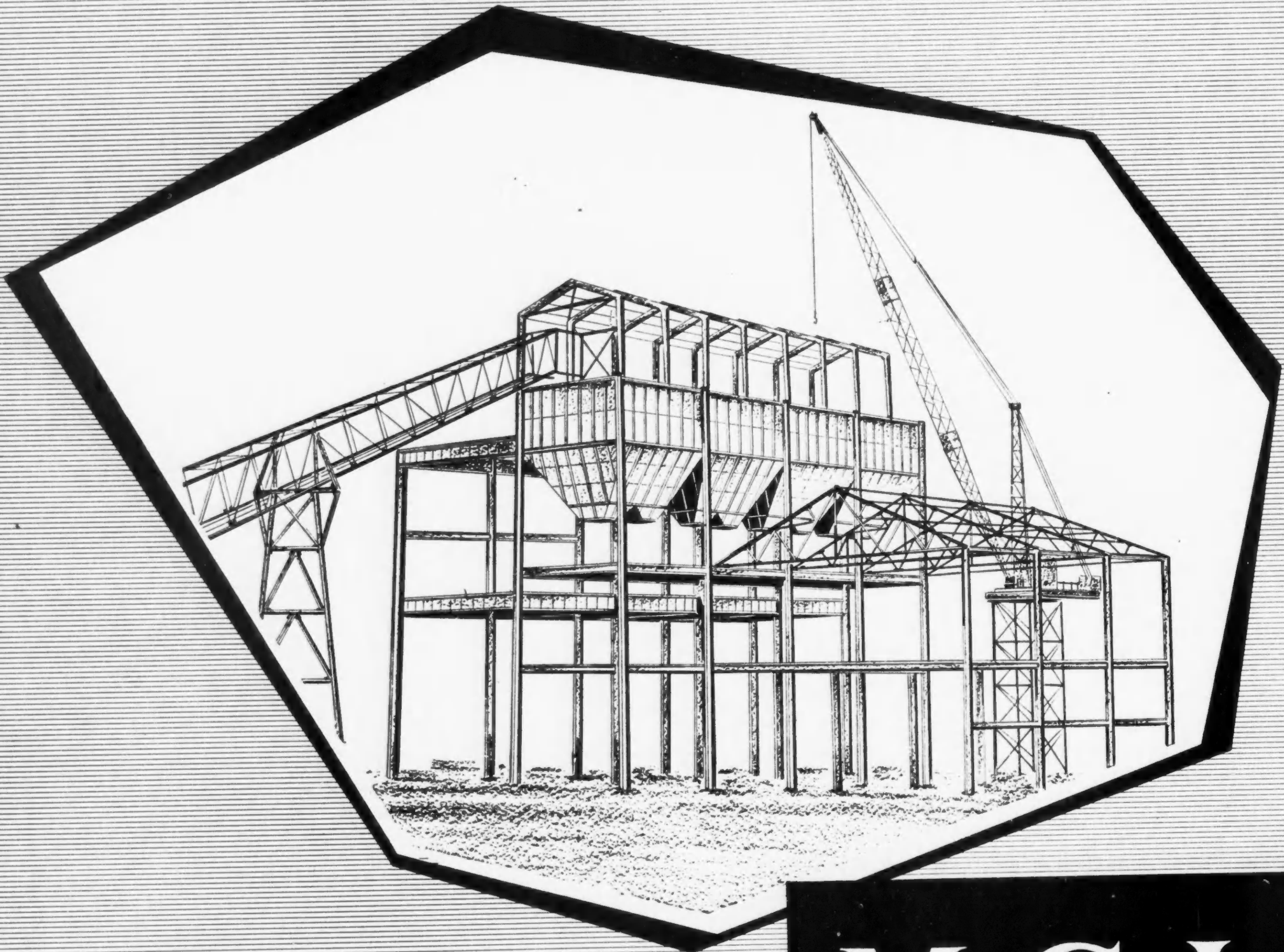

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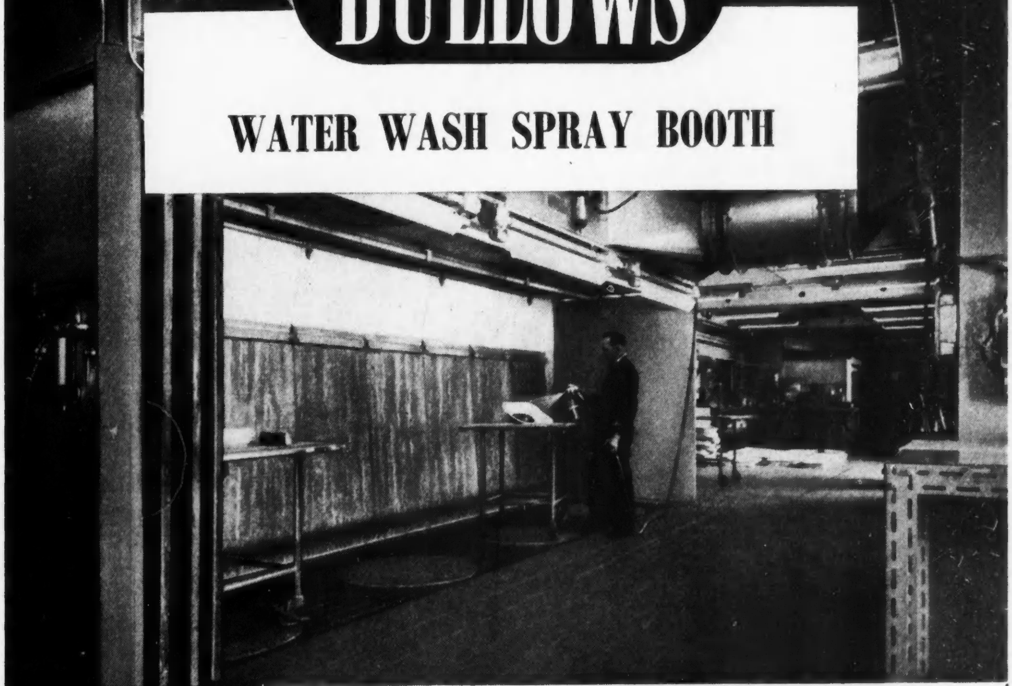

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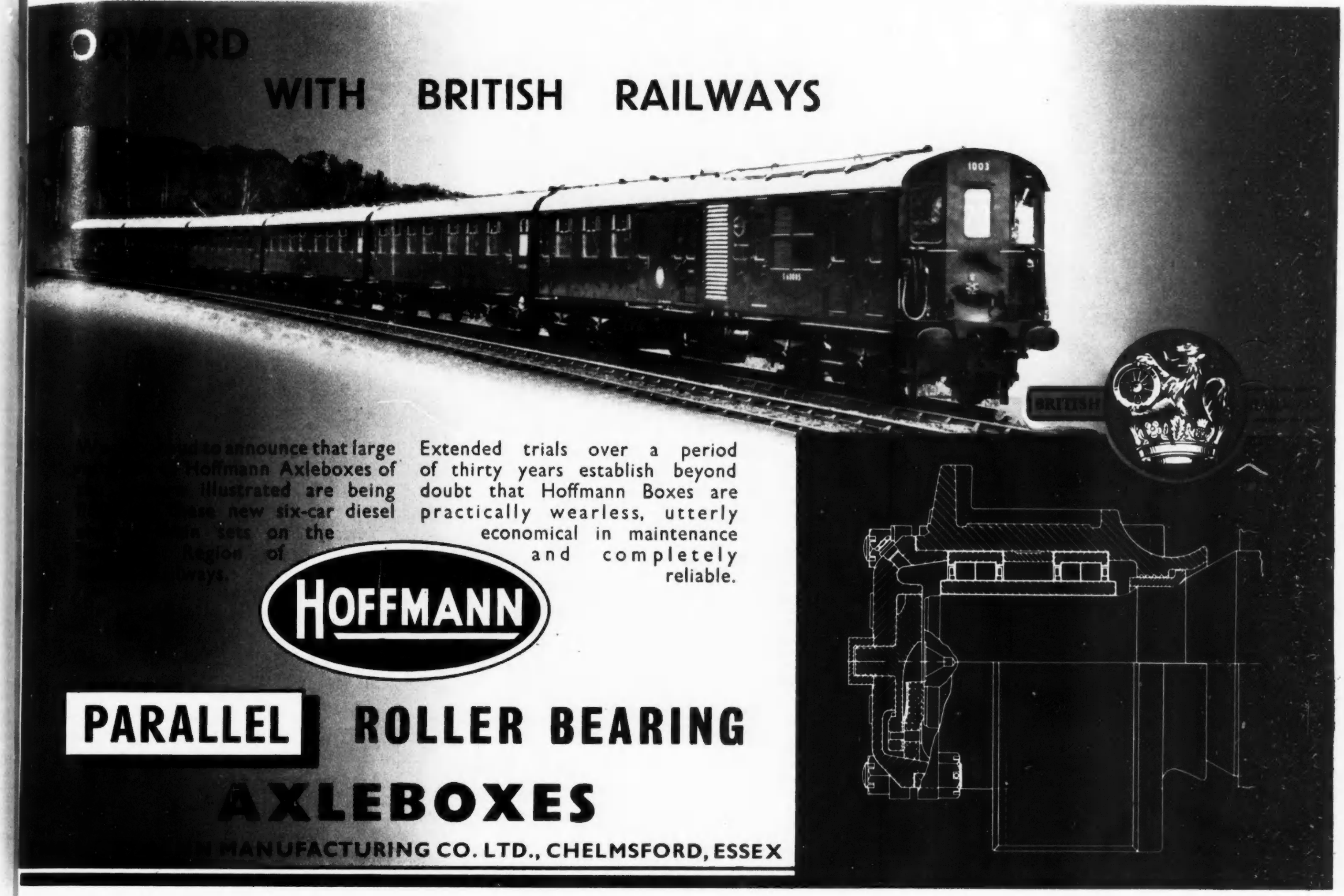

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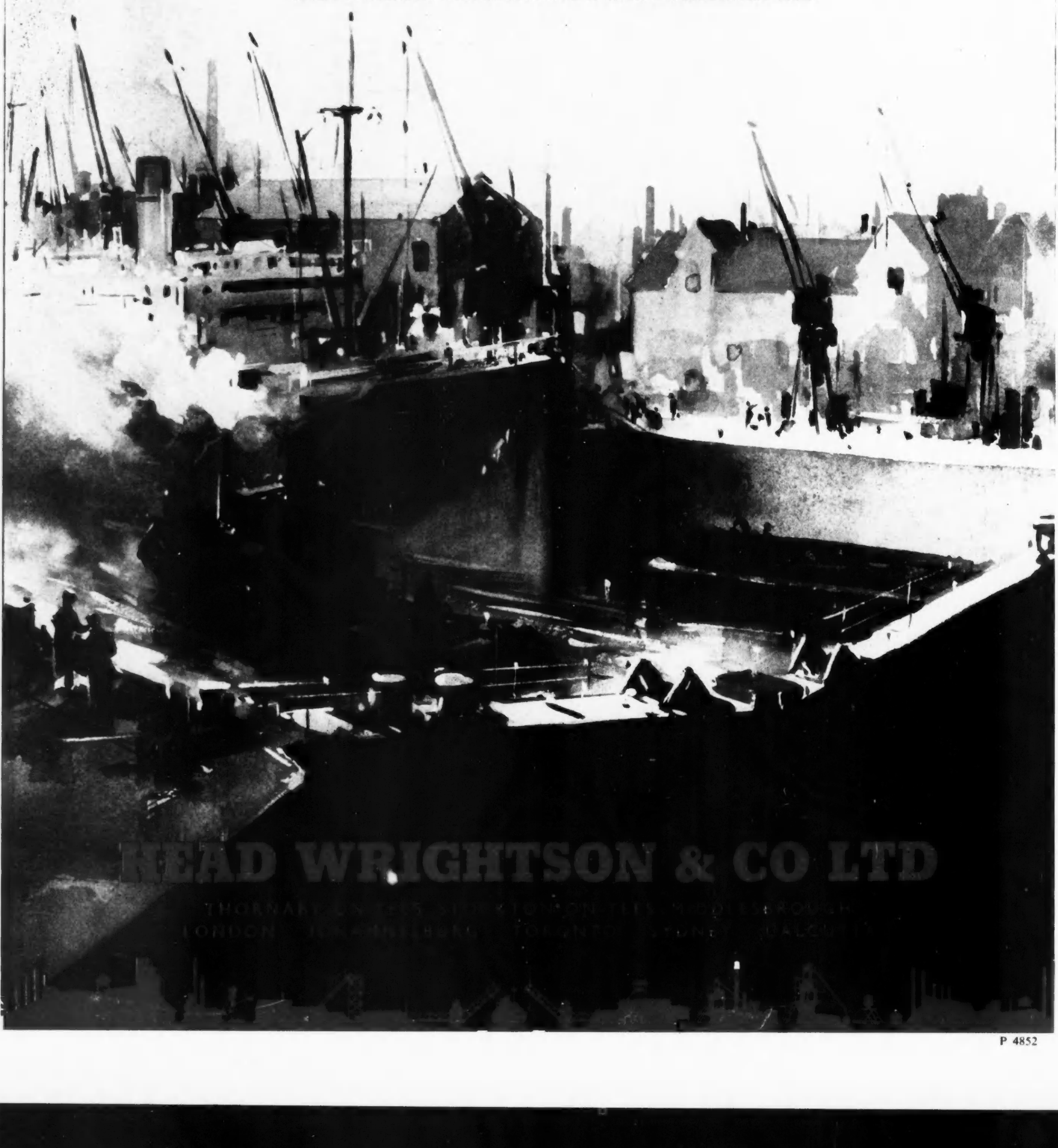

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